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CALIFORNIA FISH AND GAME

VOLUME 44 JANUARY, 1958 NUMBER 1

Published Quarterly by the
CALIFORNIA DEPARTMENT OF FISH AND GAME
SACRAMENTO

PERIODICAL
California fish & game
v. 44-45
1958-59
2439

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THE CHUKAR PARTRIDGE IN CALIFORNIA[1]

HAROLD T. HARPER, BEVERLY H. HARRY, and WILLIAM D. BAILEY
Game Management Branch
California Department of Fish and Game

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[1] Submitted for publication June, 1957. Funds for this study were provided through Federal Aid in Wildlife Restoration Projects W-44-R, "Chukar Survey", and W-47-R, "Upland Game Investigations". The food habits data were provided through Project W-25-R, "Food Habits Investigations".

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INTRODUCTION

It became apparent by the late 1940's that the chukar partridge (*Alectoris graeca* subsp.), an exotic upland game bird, was becoming established in certain areas in California. By 1952, the chukar was familiar to enough sportsmen in the southern portion of the State to create a growing demand for a hunting season. The chukar has become established in many of the central and southern desert mountain ranges and in the arid sections of the eastern side of the south coast mountain ranges.

Before initiating an open season on the birds, information on the distribution, habits, and management of this little-known species was gathered. The initial phase of the study, started in 1952, was concerned with a statewide survey to determine distribution and numbers. In 1954, two areas where chukars occurred in good population were selected to conduct an intensive study of the habits and requirements of this bird in order to evolve sound management procedures. The desert-type mountain ranges of Inyo and Mono counties, and the Temblor Range of Kern and San Luis Obispo counties, were chosen for the study.

California's first chukar season, established in 1954, was a direct result of these investigations.

ACKNOWLEDGMENTS

The authors wish to express their appreciation for the assistance of several individuals who aided in procuring much of the information presented in this study. Wildlife Protection Officers Howard Martin and Robert Fischer gave their full support, and without their aid the project would have been seriously handicapped. The following Game Management Branch personnel are especially thanked for their assistance: Howard Bilton, Arthur Hensley, Bill Farschon, David Selleck, Gene Gerdes, Bill Wagner, and Mark Halderman. Also, appreciation for assistance in manning hunting season checking stations is due to personnel of Regions 4 and 5. Our gratitude to the following agencies is expressed: United States Naval Ordnance Testing Station at China Lake, California; the Death Valley National Park Rangers; and the United States Weather Bureau personnel at Bishop, California.

Our special thanks are given to Donald D. McLean, Upland Game Project Leader, who guided and aided the chukar section personnel in carrying out the study, and to Howard Leach and Bruce Browning of the Food Habits Laboratory, who prepared the food habits data.

HISTORY OF CHUKAR LIBERATIONS

The first chukars acquired for breeding stock by the Department of Fish and Game were obtained from Mr. Leland Smith, a private game breeder of Woodland, California. This stock was purchased originally from a game handler in Calcutta, India, in 1928 by Mr. Frank Booth and was apparently of the race *Alectoris graeca chukar*.

An additional 10 chukars (nine males and one female) were imported by the Department from Calcutta, India, and were thought to be of the race *chukar*. The original game farm breeders were derived from this stock and the birds procured from Mr. Smith.

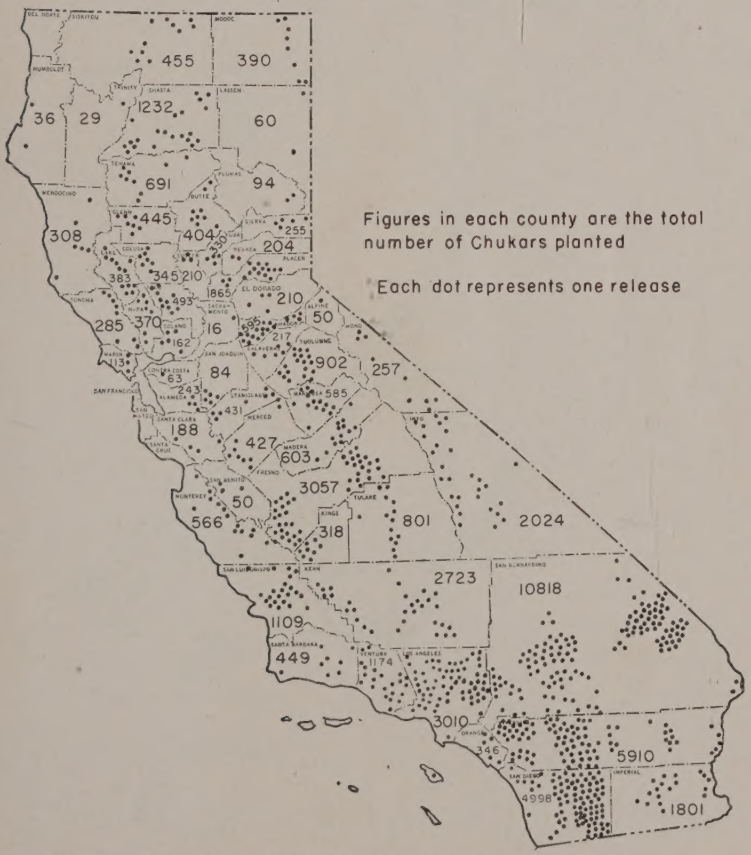


FIGURE 1. Map of California, showing plantings of game farm chukars by county. *Drawing by Cliffa Corson.*

The Department liberated the first chukars in 1932 in three counties: Riverside received 134, San Bernardino 36, and Shasta 28. Chukars were planted in all except four counties in California by 1953. These were: Del Norte, Santa Cruz, San Mateo, and San Francisco. From the first liberations in 1932 through December, 1955, 52,184 game farm reared chukars were released.

The California Fish and Game Commission set a policy in 1947 eliminating the planting of game farm chukars north of the Tehachapi Mountains and in Inyo County. This was done in order to see if the birds would continue to flourish without benefit of a stocking program.

Additional plantings of game farm chukars continued in the southern counties through 1955. Trapping of wild chukars began in 1953, with the trapped birds transplanted to unstocked areas similar to the areas where chukars had become established. During the period 1953-1955,

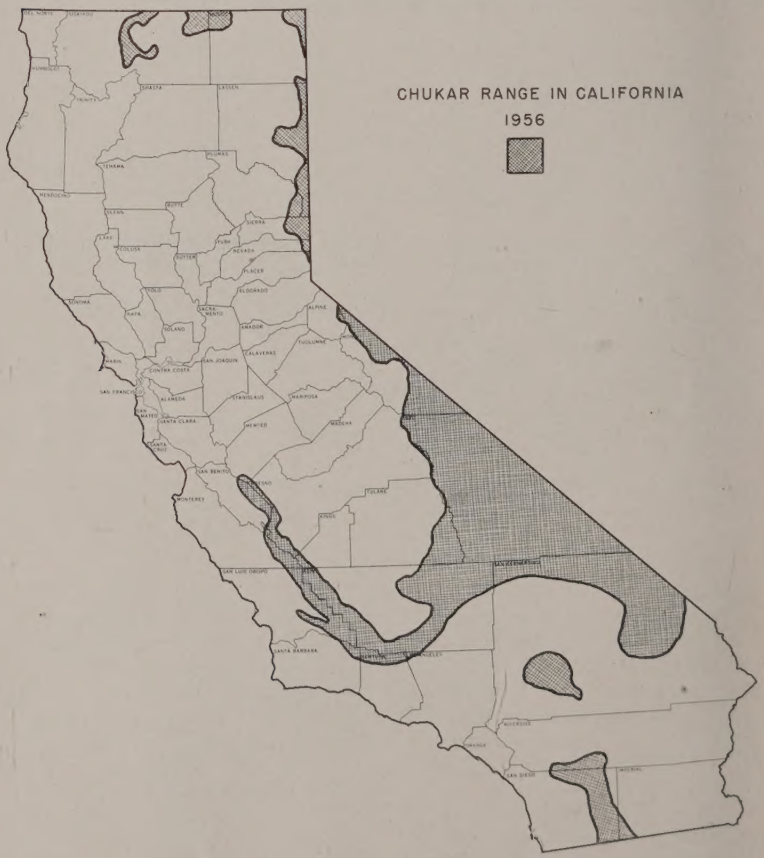


FIGURE 2. Chukar range in California as of 1956. *Drawing by Cliffa Corson.*

2,899 wild-trapped chukars were stocked in seven counties in the State. The number of game farm chukars released in the various counties during the years 1932 through 1955 varied from 16 in Sacramento County to 10,818 in San Bernardino County (Figure 1).

SUCCESS OF CHUKAR PLANTINGS IN CALIFORNIA

Each county where chukars were released was checked during 1952 and 1953 to determine the success of the plant or plants. Success of these liberations varied from successful establishment to complete failure. However, in some of the areas where the chukar failed, the numbers liberated were too few to provide a good test. Chukars were liberated in almost every conceivable type of terrain—from dense stands of timber and brush in the coast ranges and Sierra Nevada to the arid,

FIGURE 3. Isohyets. By examining Figure 2, it may be seen that chukar distribution follows generally the 5-to 20-inch rainfall lines. *Drawing by Cliffa Corson.*

bare desert lands; from areas where annual precipitation exceeded 50 inches to areas where it was less than five inches. In almost all instances establishment was most successful in the semiarid sections of California (see Figures 2 and 3). Little success was apparent in the north coastal area, the outer coast range, and the western slopes of the Sierra Nevada. The annual precipitation usually exceeded 20 inches in areas of failure.

It became noticeable during the statewide survey that the race of chukars stocked was not tolerant of dense brush or timber, or of areas of high annual rainfall. Figures 4 and 5 show the typical type of habitat in the Inyo Mountains where chukars are established, and Figures 6 and 7 are representative of chukar habitat in the Temblor Range in Kern and San Luis Obispo counties.

STUDY AREAS

Inyo-Mono Area

The Inyo-Mono area is interspersed with high mountain peaks, dry alkaline lake beds, small fertile valleys, and large expanses of granitic and volcanic rock.

The annual precipitation varies from three inches in the drier valleys to over 40 inches on the high mountain peaks. Winters are cold and the temperature often drops below zero in the valleys. The summers are warm and dry. Occasional summer thunderstorms occur, but most of the precipitation occurs on the higher peaks. Snowfalls are seldom deep in the valleys, and the ground is usually free from snow within a few days. The high mountain peaks are covered with snow throughout the winter months, and patches of snow remain through the summer. Table 1 shows the precipitation and temperatures for 1952-1955 for the town of Bishop, which is located near the center of the study area. This town is in northern Owens Valley between the Sierra Nevada and the White Mountains, which ascend to over 14,000 feet on the highest peaks.

Topography

Differences in elevation are greater here than in any other place in the United States, with the lowest point, in Death Valley, 280 feet below sea level, and the highest peak, Mt. Whitney, 14,495 feet above sea level. Many peaks in the area exceed 10,000 feet. Valleys and plateaus range in elevation from 3,500 feet to about 7,000 feet, except for Death Valley. Deep, rough, rocky canyons are common throughout the mountains. Huge mountains with walls of solid granite are found on the eastern slopes of the Sierra Nevada and in the White Mountains. Vast fields of volcanic rock are common throughout much of the region.

Water

Permanent water is scarce in much of the desert ranges. The Owens River flows the length of Owens Valley, but a large aqueduct carries off the largest part of the river, leaving very little for irrigation purposes. Small streams flow down the eastern slopes of the Sierra and from the western and eastern slopes of the White Mountains; the remaining area is almost without flowing water. Springs and seeps are few and guzzlers (artificial watering devices) have been installed to supplement the supply of water for upland game.

FIGURE 4. Typical chukar habitat in the Inyo-Mono area. *Photograph by W. Bailey.*

FIGURE 5. Typical chukar habitat in the Inyo-Mono area. *Photograph by W. Bailey.*

FIGURE 6. Typical chukar habitat in the Temblor Mountains. The Upper Quality Canyon guzzler is shown in the right foreground. The guzzler is well placed in that it is on a bench overlooking a steep canyon. *Photograph by H. Harper.*

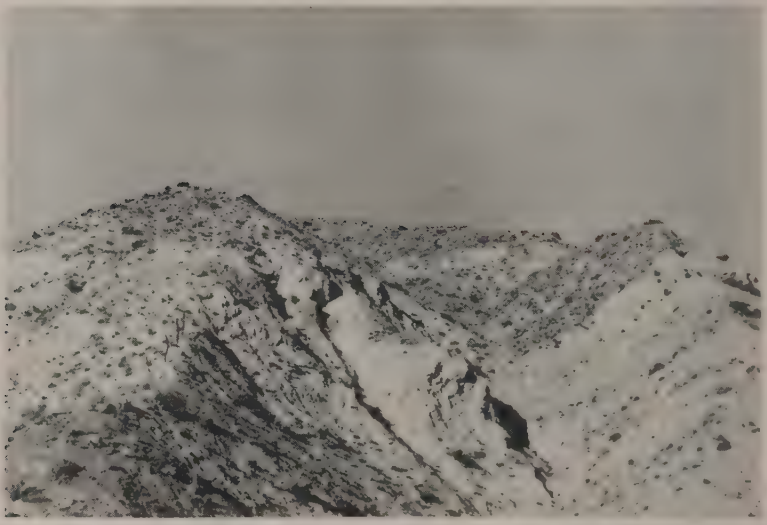


FIGURE 7. View of Temblor area chukar habitat. *Photograph by H. Harper.*

TABLE 1

Climatological Data—Inyo-Mono Area
U. S. W. B., Bishop, California, 1952-1955

Elevation: 4,108 feet
Period of record: 28 years

	Precipitation (inches)				Departure from normal (inches)				Average monthly temperature (degrees F.)				Departure from normal (degrees F.)			
	1952	1953	1954	1955	1952	1953	1954	1955	1952	1953	1954	1955	1952	1953	1954	1955
January	5.03	0.11	1.68	1.81	+3.62	—1.01	+0.56	+0.69	30.4	43.5	38.0	27.2	—7.5	+5.6	+0.1	—10.7
February	trace	trace	2.21	0.19	- 0.94	- 0.91	+1.30	—0.72	41.3	42.2	46.4	37.8	0.0	+0.9	+5.1	—3.5
March	2.05	0.27	1.00	trace	+1.27	—0.39	+0.34	—0.66	40.6	47.5	43.8	45.5	—6.8	+0.1	—3.6	—1.9
April	1.02	0.15	trace	0.41	+0.78	- 0.10	0.25	+0.16	54.8	54.1	58.6	49.9	+0.1	+0.6	+3.9	—4.8
May	trace	1.17	0.18	0.88	—0.28	+0.97	—0.02	+0.68	64.2	55.5	66.9	58.2	+1.6	—7.1	+4.3	- 4.4
June	0.03	0.03	0.02	0.00	0.07	- 0.07	—0.08	—0.10	67.1	68.0	70.0	69.2	- 2.3	—1.4	+0.6	- 0.2
July	0.02	0.19	0.16	0.04	+0.10	+0.09	+0.06	—0.06	76.7	79.6	77.4	74.8	+1.2	+4.1	+1.9	—0.7
August	trace	0.03	0.00	0.22	—0.11	—0.11	—0.14	+0.08	75.0	72.6	71.2	75.8	+3.2	—0.9	—2.3	+2.3
September	0.09	trace	0.14	0.14	- 0.09	0.19	—0.05	- 0.05	67.9	70.0	65.8	67.0	+0.6	+2.7	—1.5	+0.3
October	0.00	0.12	0.00	trace	- 0.24	—0.22	—0.34	—0.34	60.8	55.1	56.5	58.4	+3.7	—2.0	0.6	+1.3
November	0.53	0.38	0.85	0.09	+0.11	—0.10	+0.37	—0.39	41.9	46.5	48.4	45.3	—4.3	+0.3	+2.2	- 1.1
December	1.15	0.13	0.95	4.02	+0.22	- 0.76	+0.06	+3 13	36.8	39.6	37.3	39.1	—2.3	+0.5	—1.8	0.0
Annual	10.10	2.58	7.19	7.80	+4.37	—3.15	+1.46	+2.42	54.8	56.2	56.7	54.0	—1.2	+1.2	+1.8	- 1.0

Extremes — Highest — Lowest — Normal annual rainfall 5.38 inches

Precipitation — 14.93 inches — = 0.80 inches

Temperature — 109 degrees F. — —15 degrees F.

Vegetation

The valley floors are sparsely covered with shrubs and grasses that are tolerant of low precipitation. As higher elevations are reached on the slopes of the mountains, juniper, piñon pine, and mountain-mahogany are found. The drier plateaus are interspersed with Joshua tree (*Yucca brevifolia*), cacti, rabbitbrush (*Chrysothamnus* spp.), sagebrush (*Artemisia* spp.), and other desert shrubs. Brome grass (*Bromus* spp.) and needle grass (*Stipa* spp.) are found where soil conditions permit.

Agriculture

Only a small portion of the area is under cultivation. A few small ranches utilize the water flow from the White Mountains, and ranches along the Owens River may get enough water from this river during wet years to irrigate crops. The principal crops grown are potatoes, corn, and alfalfa. Sheep and cattle are ranged over the high plateau country in Mono County, and cattle are grazed on much of the desert ranges.

Feral burros are common, and wild horses are found on some ranges.

Temblor Area

The Temblor Range is a range of rolling hills, 6 to 10 miles in width and extending in a northwesterly-southeasterly direction a distance of approximately 40 miles in Kern and San Luis Obispo counties. The Temblors are bounded on the east by the San Joaquin Valley and on the west by the Carrizo Plain. The maximum elevation is 4,332 feet. Erosion has created numerous small, steep-sided gullies and canyons on both sides of the range. The northern part has rolling tops that are utilized for dry-farming cereal grains.

Large rock outcrops are uncommon. On the east slopes, shale and sandstone have been exposed by erosion. Small, scattered, granitic rocks are found in one small area on the west slope. Climatological data are given in Table 2.

Water

Flowing streams are practically nonexistent in this area. One small, alkaline stream in the southern part flows for approximately one mile and then disappears into the streambed. A few seeps and springs are found on both the east and west slopes, but these are often several miles apart. Stock watering troughs are scattered throughout the range, and these are filled with water piped from wells near the valley floor. However, after the stock is removed from the range, water is no longer pumped to the troughs, and they go dry in July or August. The Department of Fish and Game has installed 23 guzzlers in the range.

Vegetation

Much of this area is barren of shrubs and only grasses and forbs form the ground cover. On the eastern slopes the predominant shrubs are saltbush (*Atriplex* spp.), burro-weed (*Franseria dumosa*), gold-enbush (*Haplopappus acradenius*), and blue oak (*Quercus douglasii*). The western slopes differ in that here burro-weed, desert tea

TABLE 2

Climatological Data—Temblor Area

U. S. W. B. Substation, Maricopa, California, 1952-1955 — Elevation: 680 feet

	Precipitation (inches)				Departure from normal (inches)				Average monthly temperature (degrees F.)				Departure from normal (degrees F.)			
	1952	1953	1954	1955	1952	1953	1954	1955	1952	1953	1954	1955	1952	1953	1954	1955
January	2.21	0.67	2.47	2.43	+1.15	—0.30	+1.50	+1.46	46.5	51.1	48.7	--	—0.8	+0.41	+1.7	--
February	0.73	0.42	0.25	0.68	—0.33	—0.55	—0.72	0.29	52.1	51.2	51.8	51.1	0.5	—1.3	—0.7	—1.4
March	2.41	0.12	1.38	0.03	+1.42	—0.85	+0.41	—0.94	52.0	56.7	55.4	58.0	—5.5	—0.6	—1.9	+0.7
April	0.49	0.85	0.02	0.33	—0.14	+0.26	—0.57	—0.26	63.7	62.4	67.4	--	+0.5	—1.2	+3.8	--
May	0.00	0.03	0.00	0.43	—0.34	—0.31	—0.34	+0.09	74.1	65.3	74.9	71.7	+3.1	—5.8	+3.8	+0.6
June	0.00	0.00	0.00	0.00	—0.11	—0.10	—0.10	—0.10	72.0	73.0	76.9	77.7	—6.6	—5.9	—2.0	—1.2
July	0.00	trace	0.00	0.00	—0.01	—0.01	—0.01	—0.01	86.6	87.7	86.6	81.9	+1.0	+2.1	+1.0	—3.7
August	trace	0.04	0.00	trace	—0.02	+0.02	—0.02	—0.02	84.5	79.3	79.1	86.4	—0.6	—4.5	—4.7	+2.6
September	0.01	0.00	0.00	0.00	—0.10	—0.11	—0.11	—0.11	79.7	79.0	75.8	79.3	+3.1	+2.1	—1.1	+2.4
October	trace	0.00	0.00	0.00	—0.32	—0.29	—0.29	—0.29	71.8	66.5	67.6	69.2	+4.7	—0.7	+0.4	+2.0
November	0.85	1.01	0.49	0.41	+0.48	+0.62	+0.10	+0.02	54.1	56.5	54.6	54.2	—2.8	—0.1	2.3	—2.7
December	1.82	trace	0.76	0.55	+0.84	—0.92	—0.16	—0.37	49.1	48.2	45.4	--	+0.3	—0.5	—3.3	--
Annual	8.52	3.14	5.37	4.86	+2.52	—2.54	—0.31	—0.82	65.5	64.8	65.3	--	—0.3	—1.0	—0.5	--

Extremes Temperature extremes during 1952-1955 — Highest 110 degrees F. — Lowest 21 degrees F.

Normal annual rainfall- 5.68 inches

Precipitation data unavailable

(*Ephedra* sp.), and chaparral yucca (*Yucca whipplei*) are found in abundance. Small junipers (*Juniperus* sp.) and oaks are occasionally scattered near the tops, and willow (*Salix* sp.) and cottonwood (*Populus fremontii*) are found in a few canyons. The principal low ground cover is composed of filaree (*Erodium* spp.) and brome grass.

Agriculture

Dry farming of cereal grains along the rolling hilltops and in the small valleys is common in the area. The fields seldom exceed 200 acres in extent. Irrigated crops are not grown.

Livestock is grazed throughout the range. Large flocks of sheep are moved onto the range in the spring to crop the short grasses and filaree. Cattle are grazed in some areas throughout the year.

LIFE HISTORY

Mating Activities

Wintering flocks of chukars begin scattering and pairing in the Temblors during early February. In the Temblor area, pairing has been observed during the first week in February, and in the Inyo-Mono area, in late February and early March. The difference in time of pairing between the two areas is due to the lower temperatures prevailing in the Inyo-Mono area.

In the Inyo-Mono region the earliest mated pair was seen on February 11, and in the Temblors on February 6.

Calling is more prevalent during the prenesting period than at any other time of the year.

In the Inyo-Mono area, paired birds were observed from 4,200 to 7,000 feet in elevation during March; however, reliable reports were made of chukar tracks in the snow during the same period at the 9,000-foot level. The distribution of chukars in the Temblor Range during the prenesting activities varies from the 1,000-foot level in the small valleys to the highest elevations, since snow does not limit the altitudinal distribution during the period.

Grouping of adult chukars during the nesting period is an indicator of a poor nesting season. Regrouping of mated pairs or failure of chukars to pair has been observed in both the Inyo-Mono and the Temblor areas from April through June, when the height of mating and nesting occurs. Regrouping of adults, without broods, during that period indicates nesting failure or failure to pair due to some physiological disturbance. In the Inyo-Mono area, 16 percent of the adult chukars observed during the March 20 to April 19, 1955, period, were in groups of three or more, and in the May 20 to June 19, 1955, period, 73 percent were in groups of three or more (Table 3). This failure to nest was also reflected in the adult: young ratio and the over-all population observed following the nesting season. In 1954, the percentage of groups of three or more adults was considerably lower than in 1955 (Table 3). In the Temblor area, regrouping during the nesting period in 1954 was higher than in 1955. This was reflected in a higher adult: young ratio and over-all population for 1955.

2—63550

TABLE 3

Number of Singles, Pairs, and Groups (3 or More) of Chukars Recorded During the Period March 20th to June 19th in 1954 and 1955

Area	Year	Period	Totals	Adult singles	Adult pairs	Adult groups of 3 or more	Percentage		
							Singles	Pairs	3 or more
Inyo-Mono	1954	3/20–4/19	20	2	9 (18)	0 (0)	10.0	90.0	0.0
		4/20–5/19	24	5	8 (16)	1 (3)	20.8	66.7	12.5
		5/20–6/19	25	5	6 (12)	2 (8)	20.0	48.0	32.0
		Totals	69	12	23 (46)	3 (11)	17.4	66.7	15.9
	1955	3/20–4/19	67	6	25 (50)	3 (11)	8.9	74.6	16.5
		4/20–5/19	80	11	12 (24)	6 (45)	13.8	30.0	56.2
		5/20 6/19	57	3	6 (12)	8 (42)	5.3	21.1	73.6
		Totals	204	20	43 (86)	18 (98)	9.8	42.2	48.0
Temblor	1954	3/20–4/19	25	4	7 (14)	2 (7)	16.0	56.0	28.0
		4/20–5/19	164	16	32 (64)	14 (84)	9.8	39.0	51.2
		5/20–6/19	472	5	7 (14)	29 (453)	1.1	2.9	96.0
		Totals	661	25	46 (92)	55 (544)	3.8	13.9	82.3
	1955	3/20–4/19	116	12	52 (104)	0 (0)	10.3	89.7	0.0
		4/20–5/19	144	54	40 (80)	2 (10)	37.5	55.6	6.9
		5/20–6/19	213	25	19 (38)	22 (150)	11.7	17.9	70.4
		Totals	473	91	111 (222)	24 (160)	19.2	47.0	33.8

Nesting

The first chukar nest found during the study was on May 11, 1954, in the Temblor area. In subsequent searches for nests in the Temblors during 1954, six nests that contained more than one egg were located. In 1955, eight nests that contained more than one egg were found in the Temblor area and two in the Inyo-Mono area (Table 4).

Observations indicated that nest predation is a decimating factor. Ravens are common in both the Temblor and Inyo-Mono areas and probably account for high nest losses. Of four active raven nests checked in the Temblor area in 1955, all contained identifiable remains of chukar eggs in and under the nest. One raven nest had approximately 25 chukar eggshells and another, five eggshells. In the other two nests, eggshell remains were too fragmentary to determine numbers. Chukar eggshell remains were found to be numerous along fence rows and around rock outcroppings, where ravens deposit the shells.

Chukar nests were in most instances almost completely obscured from view on three sides and the top. Two nests that could be seen from above were found, and these were subsequently destroyed by ravens. All of the active nests were well formed and lined with small twigs, dry grass, and breast feathers.

All except two nests were found on slopes of rolling hills with outcroppings of shale, sandstone, or granite. Chukars were found to have no preference in slope direction for nest location. One nest was found on a small flat and one was found in the bottom of a small wash. Preference for nesting cover was not limited to any specific growth. Nests were found under dead saltbush with grasses and red-stem filaree

FIGURE 8. Chukar hen on nest containing 16 chukar eggs and two valley quail eggs. The cover is *Haplopappus* and the locality the Temblor Mountains. *Photograph by H. Harper.*

TABLE 4

Chukar Nesting Summary—Inyo-Mono and Temblor Areas, 1954-1955 (16 Nests)

Area	Year	Date found	Number eggs	Hen on when found	Number hatched	Date	Distance from water	Cover type	Cause of destruction	Remarks
Temblor	1954	May 11	7	No	--	--	½ mile	*Atriplex*	Fox	--
		May 11	15	Yes	15	May 14	¼ mile	*Atriplex*	--	--
		May 12	8	Yes	--	--	1 mile	Grass and forbs	Raven	--
		May 18	5+	No	--	--	2 miles	*Haplopappus*	Fox	--
		May 19	12	Yes	12	May 30	¼ mile	*Atriplex*	--	--
		May 24	14	No	14	May 20	¼ mile	*Haplopappus*	--	Hatched when found
Temblor	1955	May 5	6+	No	--	--	2 miles	Buckwheat	Antelope ground squirrel	Kicked eggs from nest
		May 6	11	Yes	--	--	2 miles	Grass and forbs	Raven	--
		May 17	11	Yes	--	--	¼ mile	*Atriplex*	Coyote	Incubated 15 days; hen killed
		May 18	2	No	--	--	½ mile	*Atriplex*	Deserted	Reason unknown
		May 25	16+ 2 quail	Yes	8	June 8	½ mile	*Haplopappus*	--	Hatched 1 quail egg; other eggs cooked by sun
		May 26	10	Yes	--	--	¼ mile	*Atriplex* *Haplopappus*	Antelope ground squirrel	Kicked eggs from nest
		June 2	5+	No	--	--	½ mile	*Haplopappus*	Coyote	--
		June 19	9	No	--	--	½ mile	*Atriplex*	Antelope ground squirrel	Kicked dirt in nest
Inyo-Mono	1955	May 15	10	Yes	--	--	½ mile	*Atriplex*	Deserted	Dog flushed hen from nest
		June 14	12	No	--	--	½ mile	Grass and rocks	Deserted	Reason unknown

(*Erodium cicutarium*) growing around the base and under green saltbush, goldenbush (*Haplopappus* sp.), and desert tea (*Ephedra californica*). Some nets were found in mixed annuals, short grasses, and fiddle-neck (*Amsinckia* sp.). Figure 8 shows an incubating hen under a goldenbush.

Incubating hens were reluctant to leave nests, even when the nests were approached within a few feet. In one case the observer lifted a hen off the nest and counted the eggs without causing her to leave or desert.

Nests were found by searching areas where either single birds or pairs of chukars had previously been seen. One method which proved successful was to select an area frequented by chukars and scan the area with binoculars from daylight to about 8 a.m. When a single chukar was seen feeding in a hurried manner, it was watched until it returned to a nest. The feeding period of incubating hens was found to be from approximately one hour after sunrise to 8 a.m., and again in the afternoon from about 5.30 to 6.30 p.m. Feeding time of individual hens was found to be about one hour. Male chukars were not observed to join incubating hens when they left the nest.

Distances Chukars Nest From Water

An effort was made during the prenesting and nesting season of 1955 to determine the distances chukars range from permanent water. Eight canyons lacking water, which were typical of those found on the eastern slopes of the Temblor Range, were checked. The canyons checked were from one and one-half to three miles long and were hiked from the top to where the canyon emerged from the steep terrain onto the flats. Eighteen chukars and six valley quail were observed during the survey. In two canyons farther south, where permanent water was available in guzzlers spaced about one mile apart, 27 chukars were observed in one canyon and 18 in the other. All the chukars in these two canyons were seen within one mile of the guzzlers. Of 205 chukars, both adults and young, that were observed between the period from April to June, 1954 and 1955, 184 were within one-half mile of water. In the Inyo-Mono area during the same period, of a total of 112 chukars observed, 104 were within one-half mile of water.

Broods

Observed broods were aged to the approximate week and the dates of hatch computed from that figure. In 1954 and 1955, the peak of hatching in the Temblor area occurred between May 15 and May 29. In the Inyo-Mono area the peak of hatching in 1954 was from May 15 to May 29, and approximately two weeks later in 1955, when it was between June 6 and June 12 (Figure 9). The later hatch in this area in 1955 was probably due to the effects of a cold, dry spring. The earliest record of a brood observation made during the study was on April 28, 1955, when a brood of nine chicks, one week old, was observed in the immediate area of an experimental release made in 1954 in the Kern River Canyon.

The chukar has a long nesting season, extending from the last week in April to about the first week in August. Climatic conditions may alter the length of the nesting season, especially in the Inyo-Mono area

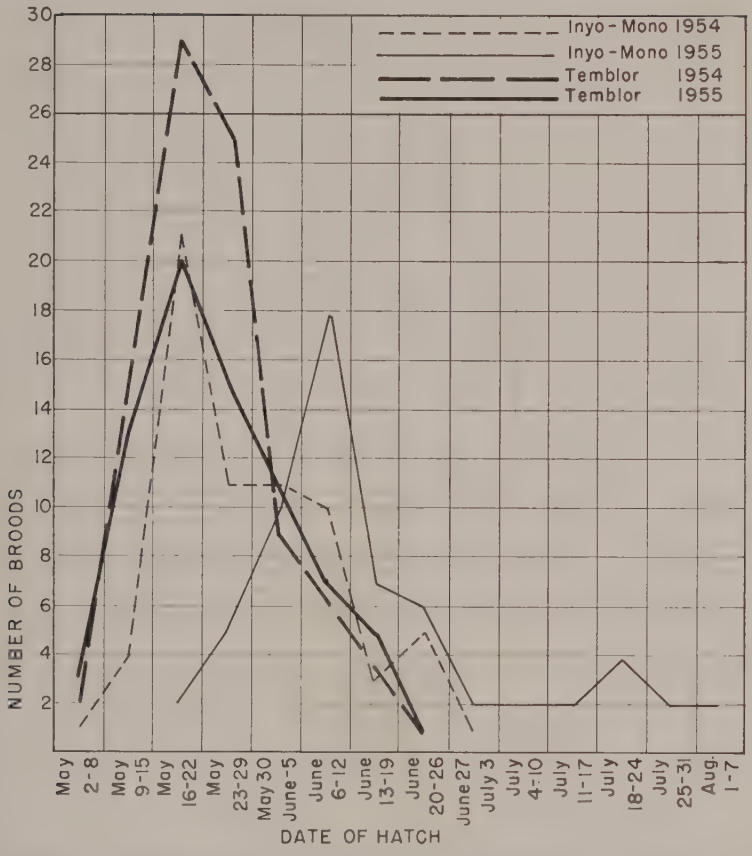


FIGURE 9. Diagram showing hatching period for chukars in the Temblor and Inyo-Mono areas. *Drawing by Cliffa Corson.*

and in the northeast section of the State where chukars are established.

Criteria used to age broods in the field were developed by observing feathering, markings, and size of game farm chicks of known ages (Table 5).

The largest brood recorded consisted of 17 chicks. During 1954 and 1955, 243 broods which were thought to be complete were counted in the Inyo-Mono and Temblor areas. The total number of chicks for all age classes through nine weeks of age was 2,180, giving an average of nine chicks per brood. It is believed, however, that accurate brood counts are not possible after the birds reach three weeks of age, due to the mixing of broods. Figure 10 presents the upward trend of brood sizes after the three-week classes were recorded.

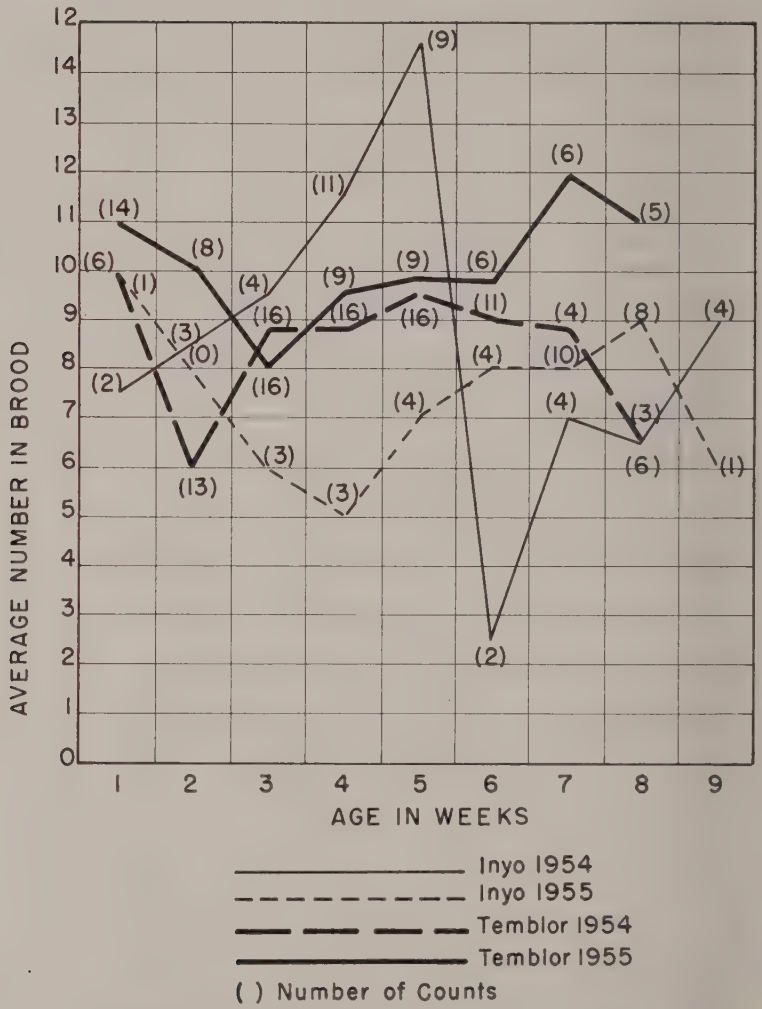


FIGURE 10. Average number of young per brood by age in weeks. *Drawing by Cliffa Corson.*

A more accurate method of determining success of the season's reproduction and brood survival is by taking young : adult ratios during July and August, when the young can be distinguished readily from the adults. The young : adult ratio of chukars for 231 classified birds in the Inyo-Mono area during July, 1954, was 3.5 : 1 ; in 1955 it was 2.1 : 1 for 196 classified birds. In the Temblor area, the young : adult ratio in 1954 was 0.8 : 1 ; in 1955, the ratio was 1.7 : 1 for 902 classified (Table 6).

TABLE 5

Criteria for Estimating Age of Broods in the Field
(Taken From Known Ages of Game Farm Chukars)

Age	Markings and characteristics
5 days	Flight: not capable, hen feigns injury. Height: approximately 2½ inches (standing). Body coloration: striped buff-brown, mottled appearance. Head: line through eye. Tail feathers: 0-1 mm.
10 days	Flight: capable, usually within two weeks or less. Height: approximately 5 inches. Body coloration: light buff under parts, spotted black. Head: black-brown spot for ear tuft; bill has black-brown upper mandible. Tail feathers: 2-3 mm.
33 days	Flight: strong. Height: approximately 6-7 inches. Body coloration: mottled-striped brown, no barring on flank. Head: eye-ring turning red; line of down along each side of head, yellow brown. Tail feathers: 5-6 mm.
47 days	Height: approximately 7-8 inches. Body coloration: barring distinctive on flanks. Head: gray crown, line of down gone, throat patch dull and gray-white, black "V" incomplete. Tail feathers: 8-9 mm., reddish tips, gray base ¾ length.
61 days	Height: approximately 9-10 inches. Body coloration: barring distinct, uniform gray-black, slightly spotted. Head: bill dominantly red-black, throat patch distinct, dull brown-white, black "V" complete, rufous ear tuft distinct. Tail feathers: 9-10 mm., reddish tips.

TABLE 6

Age Ratio of Chukars for July, 1954 and 1955—Inyo-Mono and Temblor Areas
(Field Observations)

Area	Year	Total birds	Juveniles	Adults	Ratio
Inyo-Mono	1954	231	180	51	3.5 : 1
	1955	196	133	63	2.1 : 1
Temblor	1954	662	305	357	0.8 : 1
	1955	902	573	329	1.7 : 1

The use of young : adult ratios in wild-trapped chukars is not an accurate method. In several instances during trapping operations only young were caught, and often a brood of six or seven chicks would be trapped with one hen. Among 254 chukars trapped and aged in the Inyo-Mono area in 1954, the young : adult ratio was 242 : 12 or 20 : 1; among 653 wild-trapped and aged in 1955, it was 5.7 : 1. Young : adult ratios made by classifying birds observed in the field in 1954 and 1955 were much lower than results obtained by aging wild-trapped chukars.

Factors Affecting Reproduction

The amount of precipitation occurring in the desert and semiarid regions from December through April appears to be a limiting factor for reproductive success in established chukar populations. Normal or above normal precipitation during the late winter and early spring months seems to create conditions more favorable to reproduction and nesting in the form of better vegetative growth for food and nesting cover.

From observations on reproduction success correlated with precipitation, there were higher chukar populations in the Inyo-Mono area in 1952 and 1954 than in 1953 and 1955. In the Temblor area, 1952 was a considerably better year than was 1953 or 1954. Table 7 shows the amount of precipitation and the departure from normal occurring from December through April for the years 1952-1955 and the success of reproduction based on field observations in the Inyo-Mono and Temblor areas during the same period. Temperatures in the Inyo-Mono area in 1955 during the late winter and early spring were considerably below normal and retarded normal spring vegetative growth. In the Temblor area, temperatures during the late winter and early spring growing period were almost normal during the four years of observation.

Mortality of Young and Adults

Evidence of predation by ground or winged predators was seldom reported or observed during the study. One coyote stomach was found to contain a three-quarter grown chukar. Whether this bird was caught alive or was found dead and then eaten is not known. A wildlife protection officer reported a Cooper's hawk catching a chukar. Some other reports of predation were received during the study; however, the evidence does not indicate serious inroads on chukar populations by predators.

Loss of chicks and adult chukars by drowning in stock-watering troughs, mine shafts, and other steep-sided water containers is common during the summer months. As many as 30 drowned chicks have been removed from a mine shaft. Stock-watering troughs take a heavy toll of chicks in the Temblor range. Ravens and carnivores remove many of the carcasses before they are found.

Probably the most serious predation occurs during the nesting season in the destruction of nests by ravens and ground predators.

Destruction of nests and losses of adults and young as a result of farming activities is low, since most chukar populations are found outside of agricultural areas.

Fire, especially in the Temblor range, probably accounts for the destruction of a few chukar nests and some chicks too young to fly.

Losses from starvation or extreme cold during winter were not reported. Snow seldom remains for long periods in the area south of Mono County; however, populations in the northeastern counties of California are subjected to deep snows, and some winter losses undoubtedly occur.

TABLE 7

Precipitation for Critical Months in Relation to Chukar Reproduction, 1951 to 1955

Area	Years	Months						Chukar reproduction
		December	January	February	March	April	Total	
Inyo-Mono	1951–1952	4.20	5.03	trace	2.05	1.02	12.30	Excellent
	1952–1953	1.15	0.11	trace	0.27	0.15	1.68	Poor
	1953–1954	0.13	1.68	2.21	1.00	trace	5.02	Good
	1954–1955	0.95	1.81	0.19	trace	0.41	3.36	Poor to Fair
Temblor	1951–1952	0.82	2.21	0.73	2.41	0.49	6.66	Excellent
	1952–1953	1.82	0.67	0.42	0.12	0.85	3.88	Good
	1953–1954	trace	2.47	0.25	1.38	0.02	4.12	Fair
	1954–1955	0.76	2.43	0.68	0.03	0.33	4.23	Good

Water Requirements

Chukars are limited in range by the availability of water during the hot, dry summer months. Chukars were seldom observed over one mile from water at this time of year. Of 79 broods recorded in the Inyo-Mono area in 1955, 70 were less than one-fourth mile from water, and only six were one mile or more from water. Of 110 broods in the Temblor range, 104 were within one-fourth mile from water and only one was more than one-half mile from water. Guzzlers in the Temblor area furnish the bulk of the water for broods, while in the Inyo-Mono area seeps and springs furnish most of the water.

Chukars were found to visit water sources from shortly after sunrise until about midmorning. After drinking, the birds loaf around the brush piles on the guzzlers, or near some other water supply, for several hours. Hens with broods do not loaf near water for as long a period as adults or large juveniles.

Chukars begin to disperse from the usual summer range around water in early fall, and by November are seldom observed near guzzlers or springs. Usually by November or early December precipitation has started green annuals sprouting, and the birds secure enough moisture from the green feed to fill their needs.

In some instances newly installed guzzlers have been used by chukars on the day following installation.

No attempt was made to determine the amount of water a chukar consumes at one time. The usual drinking time is from three to five minutes. One chukar was observed remaining at the water for 10 minutes and dipping its bill into the water 124 times. Single guzzler installations of 650 to 750 gallons have been completely emptied during the summer in areas where chukar and valley quail populations were high. In these areas it has been found necessary to install double units, or the new 1,200-gallon metal single units, to carry the birds through the dry period (Figures 11 and 12).

Food Habits

Chukars were collected in both the Temblor and Inyo-Mono areas for food habit analysis. Collecting was done as time permitted; therefore, the sample is not uniform in number of samples for each season of the year. The greater number of samples shown for the fall period was due to the collection of crops from hunter-killed birds during the 1954 and 1955 hunting seasons. Crops were used whenever possible; when the crop was empty, the gizzard contents were analyzed. Food items totaling less than 0.1 cc. were listed as trace items in the analyses.

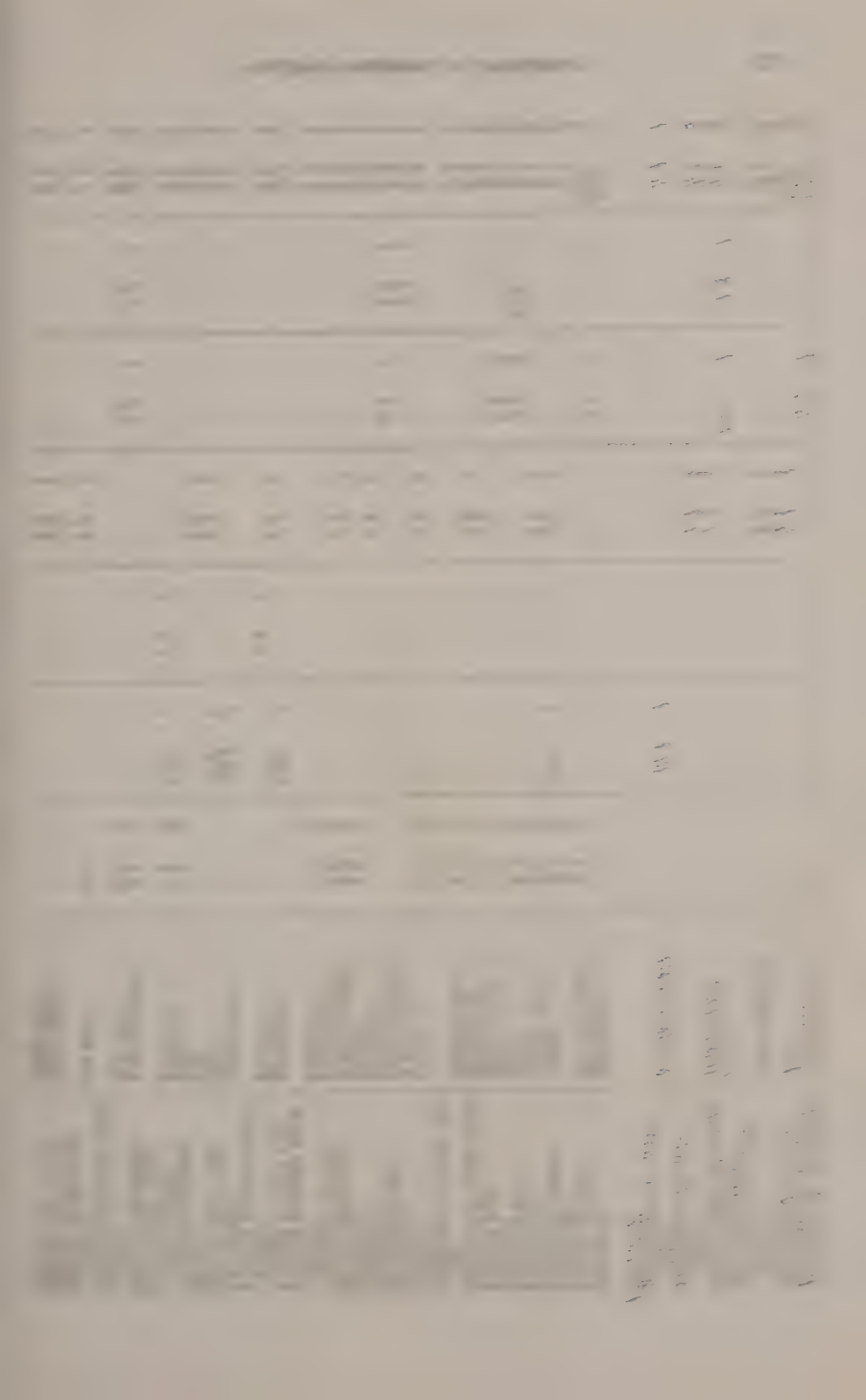
All specimens included in the tables are from adults, except for six juveniles listed in the Inyo-Mono collection for the summer season. The diet of the six juveniles showed no appreciable difference from that of the adults. A bird was considered adult if it was 12 weeks of age or over.

Inyo-Mono Area

Of the 87 specimens collected from the Inyo-Mono area, 66 were taken in the White-Inyo mountain ranges, 14 in adjacent desert mountain ranges, and seven from the east slope of the Sierra Nevada.

FIGURE 11. A double plastic guzzler unit installed in the Temblor Mountains. In 1955 over 100 chukars and 150 valley quail made use of this water supply. *Photograph by H. Harper and B. Harry.*

FIGURE 12. A 1,200-gallon steel guzzler in the process of being installed in the Temblor area. The main part of the tank is asphalt-dipped, asbestos-bonded, corrugated arch pipe. The end plates are asphalt-dipped galvanized metal. *Photograph by H. Harper.*



Chukars were collected in two distinct habitats: (1) areas influenced by agriculture and (2) areas remote from any agricultural influence. Fifty-five chukars were collected from the nonagricultural areas and 32 from areas influenced by agriculture. The nature of the agriculture consisted for the most part of cattle ranches situated on valley floors at the base of long alluvial slopes. These ranches were devoted almost entirely to the production of alfalfa hay and irrigated pasture. Cultivated grains were usually absent, but an occasional ranch had a small field of corn, barley, or oats—usually less than five acres in extent.

Sometimes small garden plots, and often a few fruit trees—usually apple, pear, or peach—were present.

It was noted during the late summer, fall, and early winter that large concentrations of chukars (200 to 800) would move onto these ranch areas. The birds were attracted from large areas of surrounding native habitat to the cultivated areas, where there was an abundance of food, especially green feed.

Table 8 is a summary of the volume percentage and frequency of occurrence of food items totaling 0.1 percent or more of the diet for any one season, listed in order of yearly importance. The yearly summarization combines the analysis of chukar crops taken from both the agricultural and nonagricultural areas after first being summarized separately on a seasonal basis. Months were grouped into seasons as follows: Winter (December through February); Spring (March through May); Summer (June through August); and Fall (September through November). Table 9 is a supplemental list of trace food items listed taxonomically.

An examination of Tables 8 and 9 reveals that 91 separate items of food were represented in the diet of 87 chukars collected from the Inyo-Mono area. The seeds of Russian thistle proved to be the staple food item of the chukar in both the agricultural and nonagricultural areas. These seeds occurred in 34 of the 87 crops analyzed and made up 16.7 percent of the yearly diet. Russian thistle is an introduced annual that is widespread and thrives wherever the native cover has been disturbed along roadsides, around waterholes, and on ranches.

The grass family was the second heaviest contributor to the chukar's diet and was utilized during all seasons and in all stages of growth. During the late winter and spring, green grass leafage and stems were readily taken, and during the summer-fall period the seeds, stems, and rootstocks became important. It is of interest to note that the chukar is capable of utilizing the entire plant. Eight crops were almost filled with the dry basal stems, roots, and leafage of perennial grasses. This is believed to be one of the advantages of a perennial grass over an annual grass. During a year of vegetative failure due to drought or other climatic conditions, stored food in the roots of perennial grasses from a previous growing season can be used as a valuable reserve food supply. Grass seeds also contribute to the diet and are taken whenever available. The grasses identified and listed in order of importance are: yellow bristlegrass, brome grass, needle grass, Indian rice grass, wild barley, fescue, and Chilean chess.

The seeds and fruits of various shrubs also contribute to the chukar's diet. Fruits of mountain rose are avidly sought whenever available and were found to completely fill the crops of six chukars collected during

TABLE 9

A Supplemental List of Trace Food Items Eaten by 87 Chukars Collected From the Inyo-Mono Area, 1950-1955

Scientific name	Common name	Frequency of occurrence
Gramineae	Grass family	7
Bromus sp.	Brome grass	6
Bromus tectorum	Cheat grass	7
Echinochloa crusgalli	Water grass	1
Eragrostis sp.	Love grass	1
Leptochloa fascicularis	Sprangle top	1
Panicum sp.	Panic grass	4
Poa sp.	Blue grass	2
Carex sp.	Sedge	1
Polygonum aviculare	Wire grass	2
Chenopodium sp.	Pigweed	2
Chenopodium ambrosioides	Mexican tea	1
Bassia hyssopifolia	Five-fingered hyssop	3
Atriplex sp.	Saltbush	3
Atriplex confertifolia	Spiny saltbush	2
Amaranthus sp.	Amaranth	5
Mirabilis laevis	Wishbone bush	2
Dalea sp.	Dalea	2
Astragalus didymocarpus	Loco-weed	7
Ceanothus greggii	Desert ceanothus	1
Sphaeralcea sp.	Mallow	2
Polemoniaceae	Gilia family	1
Linanthus sp.	Linanthus	2
Phacelia sp.	Phacelia	2
Amsinckia tessellata	Checker fiddle-neck	5
Stachys sp.	Hedge nettle	1
Compositae	Sunflower family	13
Lactuca scariola	Prickly lettuce	2
Calycoseris sp.	Tackstem	1
Chrysothamnus sp.	Rabbitbrush	6
Cirsium occidentale	Thistle	1
Vegetative stem fragments		2

the late fall. Other important fruits and seeds taken were: spiny menodora, water jacket, rubber rabbitbrush, and sagebrush. The fruits and seeds of spiny menodora occurred in 19 of 87 crops and contributed 5.3 percent of the yearly diet. Use of menodora was greatest during the summer and contributed 27.4 percent of the diet for that period.

Alfalfa leafage is a highly preferred cultivated plant. On a yearly basis it ranks fourth in volume in the diet of chukars collected near agricultural areas. Clover and white sweet clover are ranked high on the preferred list. These two plants are present in irrigated pastures and are found growing wild around many of the springs and along streams in the area. They were found frequently in chukars collected from nonagricultural areas. Some of the leafage identified as alfalfa could have been white sweet clover, since the two were difficult to separate in the crop contents.

Barley and corn were other readily taken cultivated crops.

Numerous other plants—mostly annual forbs—contributed to the remainder of the chukar's diet. The more important of these, based on frequency of occurrence, were: annual burweed, wild buckwheat, gilia, lamb's quarters, and lupine.

Locust, an introduced tree in the area, was planted in the vicinity of many of the springs and around abandoned dwellings. The seeds from

this tree were found in the crops of chukars collected in the immediate vicinity of springs and ranches.

Insects occurred in 13 of the 87 crops and appeared more frequently in the crops collected in the early summer months. Apparently, as with the young of most wild gallinaceous birds, insects form the bulk of the diet during the first few weeks of life. The crop contents of two chicks, both under two weeks of age, were examined and it was found that insect matter made up the whole of the measurable items. One crop was filled with grasshoppers, with trace occurrences of seeds of juniper, ground cherry, and pigweed. The other crop was filled with hemipterous insects.

Temblor Area

Forty-two chukars were collected from the Temblor Range. For summarization, these were grouped into two seasons: winter-spring and summer-fall. Seven specimens constituted the winter-spring sample and 35 the summer-fall sample.

TABLE 10

Principal Food Items Eaten by 42 Chukars Collected From the Temblor Range, 1950-1954
(All Items Seeds Unless Otherwise Noted)

Items		Winter-spring (7 samples)		Summer-fall (35 samples)		Yearly (42 samples)	
Scientific name	Common name	Volume percentage	Frequency	Volume percentage	Frequency	Volume percentage	Frequency
Plant foods							
Erodium cicutarium	Red-stem filaree	14.3	3	46.5	32	41.1	35
Amsinckia tessellata	Checker fiddle-neck	11.4	4	27.1	22	24.6	26
Gramineae (green leafage)	Grass family	42.2	5	0.3	3	7.3	8
Bromus tectorum	Cheat grass	--	--	6.2	17	5.2	17
Triticum aestivum	Cultivated wheat	28.6	2	--	--	4.8	2
Hordeum vulgare	Cultivated barley	--	--	5.4	2	4.5	2
Stephanomeria sp.	Desert milk aster	--	--	3.5	4	2.9	4
Montia sp.	Indian lettuce	trace	1	3.2	15	2.7	16
Unidentified seeds		--	--	2.4	1	2.0	1
Gramineae (dry, basal stems leafage)	Grass family	trace	1	1.0	2	0.8	3
Rodent pellets		--	--	0.8	5	0.7	5
Lepidium sp.	Pepper-grass	--	--	0.7	3	0.6	3
Bryophyta	Moss	--	--	0.5	7	0.4	7
Avena sativa	Cultivated oat	--	--	0.5	3	0.4	3
Unidentified forbs (green leafage)		1.4	2	0.1	5	0.3	7
Mirabilis sp.	Wishbone bush	--	--	0.3	1	0.3	1
Astragalus didymocarpus	Loco-weed	trace	1	0.3	6	0.3	7
Papaver heterophyllum	Wind poppy	1.4	1	--	--	0.2	1
Medicago sativa (green leafage)	Alfalfa	--	--	0.3	3	0.2	3
Centaurea melitensis	Napa thistle	--	--	0.3	2	0.2	2
Eremocarpus setigerus (dry leafage)	Turkey mullein	--	--	0.2	1	0.1	1
Rumex sp.	Dock	--	--	0.2	1	0.1	1
Euphorbia sp.	Spurge	--	--	0.1	2	0.1	2
Brodiaea sp. (bulb fragments)	Brodiaea	--	--	0.1	2	0.1	2
Amsinckia vernicosa (green leafage)	Shiny-seeded fiddle-neck	0.7	1	trace	3	0.1	4

Table 10 presents a summary of the food items totaling 0.1 percent or more of the diet during either seasonal period. Table 11 presents a supplemental list of the trace food items. In all, 52 separate food items were found in the 42 crops examined.

First in importance were the seeds of red-stem filaree, which contributed 41.1 percent of the yearly diet and occurred in 35 of the 42 specimens collected. This plant contributed most heavily during the summer-fall season, occurring in 32 of 35 crops and bulking 46.5 percent by volume. Second in importance were the seeds of checker fiddleneck, which accounted for 24.6 percent of the yearly diet and occurred in 26 of 42 crops. During the summer-fall period checker fiddle-neck made up 27.1 percent of the diet and occurred in 22 of 35 specimens. Together, the seeds of filaree and fiddle-neck accounted for 73.6 percent of the summer-fall diet.

TABLE 11

A Supplemental List of Trace Food Items Eaten by 42 Chukars Collected from the Temblor Range, 1950-1954

Scientific name	Common name	Frequency of occurrence
Plant foods		
Gramineae (seeds)	Grass family	1
Bromus sp.	Brome grass	4
Festuca sp.	Fescue	10
Festuca megalura	Foxtail fescue	1
Hordeum sp.	Wild barley	2
Avena barbata	Slender wild oat	3
Lolium multiflorum	Italian rye grass	1
Eriogonum sp.	Buckwheat	2
Eriogonum fasciculatum	California buckwheat	1
Cruciferae	Mustard family	1
Streptanthus sp.	Streptanthus	2
Thysanocarpus sp.	Fringe-pod	1
Lupinus sp.	Lupine	4
Trifolium sp.	Clover	8
Lotus sp.	Trefoil	1
Lotus humistratus	Hill lotus	7
Erodium moschatum	White-stem filaree	2
Croton californicus	Croton	1
Rhamnus crocea	Red-berry	1
Mentzelia sp.	Blazing-star	3
Gilia sp.	Gilia	1
Linanthus sp.	Linanthus	2
Phacelia sp.	Phacelia	2
Trichostema sp.	Blue curls	1
Madia sp.	Tarweed	4
Unidentified seeds		4
Vegetative fragments		3
Animal foods		
Insecta fragments	Insects	7

Grass leafage ranked third in importance on an annual basis and constituted 8.1 percent of the yearly diet. Grass was of little importance during the summer-fall period. It totaled only 1.3 percent of the diet; however, it made up 42.2 percent and ranked first in importance during the winter-spring period. During the winter-spring months the leafage taken consisted of green grass and was thought to consist

mainly of cheat grass—the dominant range grass in this area. The seeds of cheat grass were of less importance during the summer-fall season, contributed only 6.2 percent by volume, and occurred in 17 of 35 crops. Other wild grass seeds that occurred most frequently were those of fescue and wild oat. They contributed but a negligible amount by volume.

Cultivated wheat and barley appeared in six crops. These grains appeared to be highly preferred, and when available usually made up the entire crop contents.

The remainder of the diet consisted mostly of the seeds of annual forbs such as Indian lettuce, loco-weed, hill lotus, and clover.

Seasonal and Altitudinal Distribution

Chukars were found throughout the Inyo-Mono and Temblor areas, wherever water was available, from June through September. Altitudinally, they were observed from below sea level in Death Valley to 12,000 feet in the White Mountains and Sierra Nevada.

Deep snows in the White Mountains and Sierra Nevada move the birds to lower elevations along the valleys. In the Temblors and most of the Inyo-Mono area, snows seldom cause any downward movement.

In the fall and winter, after green feed and moisture become plentiful, chukars move into areas not occupied during the summer. During this period chukars were found near the top of the Temblor Range. Small groups of birds were found scattered throughout suitable feeding areas in the Inyo-Mono area.

Distances Moved

Band returns indicate that chukars are capable of moving considerable distances in a relatively short time. One chukar was shot during the 1955 hunting season 20 miles from where it was banded three months previously. Another band recovery was made 33 miles from the place of banding after a lapse of two years and three months. The chukar is capable of moving into suitable habitat in a short period of time.

Competition With Native Game

Evidence of chukars competing or conflicting with native game to any serious extent was not indicated during the study. The only competition which might occur would be in areas where water supplies are limited, such as in guzzlers, where the problem could be easily eliminated by placing double units or larger containers in the area. Valley quail, mountain quail, doves, rabbits, and other wild life were observed to use the same water source compatibly. Only one instance of conflict was recorded —an adult chukar was observed killing a Gambel quail chick at a waterhole.

Occasionally, groups of chukars with a single quail in their midst were seen, and in several instances a single chukar in a covey of valley quail was observed. Such instances are thought to result from the hatching of quail or chukar eggs in the nests of the other species.

Competition for food was not prevalent, since the chukar utilizes the more open knolls and flats, which are not frequented by other game.

Conflicts With Agriculture

One instance of damage to a harvested crop was reported from Benton, Mono County. The annual potato crop had been stored in a thatch-roofed shed. Chukars fed on the thatching during the severe winter of 1951-1952, and in so doing ate and scratched holes through it to such an extent that over one ton of potatoes was frozen.

Damage to agricultural crops by chukars was occasionally reported in the Inyo-Mono area and in the Lucerne Valley region of the Mojave Desert, but not in the Temblor area. Crop depredation by the chukar was considered light in all cases reported and of little economic importance.

Crops that were taken were growing in the immediate vicinity of desert mountain ranges in all cases of reported damage. During years of drought, chukars moved down from the higher slopes of the mountain ranges to feed upon green vegetation around small ranches and farms.

The reports of crop damage are summarized in Table 12.

Chukar numbers in areas where crop damage is prevalent can be reduced by trapping the depredating birds. Several hundred chukars that were causing damage to alfalfa fields adjacent to the mountains were removed from the Lucerne Valley by trapping in 1954 and 1955.

TABLE 12

Crops Damaged by Chukars

Type of crop taken	Parts eaten	Season in which damage occurred
Orchard		
Apples	Fruit	Summer and fall
Pears	Fruit	Summer and fall
Peaches	Fruit	Fall
Apricots	Fruit	Fall
Grapes	Fruit	Fall
Garden		
Potatoes	Vines-tubers	Fall
Beans	Vines-pods	Summer-fall
Watermelons	Fruit	Fall
Tomatoes	Fruit	Fall
Corn	Seedlings-kernels	Spring-fall
Grain		
Wheat	Heads-seeds	Summer-fall
Oats	Seeds	Summer-fall
Pasture		
Alfalfa	Leafage	Summer-fall
Clover	Leafage	Summer-fall

Diseases of Chukars in the Wild

Of the hundreds of chukars handled during the hunting season checks, food habits collections, and trapping operations, only four showed apparent symptoms of serious disease. Three of the diseased birds were of wild stock and one was a game farm bird. All exhibited similar symptoms—wasting away of the breast muscles and an extreme lightness. Two wild birds were collected during August, 1953, and one during November, 1954. The game farm bird was collected two months

after release. All of the diseased birds taken were from the Inyo-Mono area. No diseased or sick birds were found in the Temblor area.

Autopsies were performed by the departmental disease laboratory, but no positive diagnosis of the cause of the wasted condition could be determined. Two of the birds were in a state of advanced decomposition when the examinations were made.

No other attempts were made to determine diseases or parasites of wild chukars.

TRAPPING AND STOCKING

The first attempt to wild-trap chukars for stocking was made in 1953. Since then through 1956, 2,899 wild chukars have been trapped and released in areas not having established chukar populations (Table 13). An additional 419 chukars were trapped, banded and marked, and released at trap sites to determine movements and hunting season returns (Table 14).

TABLE 13

Numbers of Wild-trapped Chukars Released in California, 1953-1956

Year released	Numbers released	County
1953	100	San Bernardino
	73	Fresno
	198	Kern
	22	San Benito
Total	393	
1954	499	San Bernardino
	60	Riverside
	98	Fresno
	421	Kern
	197	San Benito
Total	1,275	
1955	30	San Bernardino
	167	Riverside
	150	Imperial
	114	Fresno
	354	Kern
	185	Merced
Total	1,000	
1956	152	Kern
	59	Fresno
Total	211	
Grand total	2,899	

One group of 64 game farm and 50 wild chukars were liberated in 1954, in the vicinity of a spring in the Kingston Mountain Range, northeastern San Bernardino County. The purpose of the liberation was to determine if the game farm and wild chukars would mingle, with the wild chukars "showing the way" for game farm birds. A followup of this liberation three months later disclosed that the two groups did not mingle. Of 46 chukars observed during the check, 21 were game

4—63950

TABLE 14

Numbers of Chukars Trapped and Released at Trapping Sites by Project W-47-R, With Known Returns, 1952-1955
Inyo-Mono and Temblor Areas

Area	Year trapped	Number banded	Number returns	Distance moved	Time interval	Remarks
Inyo-Mono	1952	193	6	One to 10 miles	1 month	Poacher kill
				Three to none	1 year 1 month	Retraps
				One to 2.5 miles	2 years 3 months	Retrap
				One to 33 miles	2 years 3 months	Hunter return
	1954	45	2	None	1 month	Hunter return
	1955	2	1	None	1 month	Hunter return
Temblor	1953	27	1	None	5 months	Drowned in tank
	1955	142	6	Two to none	3 months	Hunter returns
				One to 4 miles	3 months	Hunter returns
				One to 6-8 miles	3 months	Hunter returns
				One to 20 miles	3 months	Hunter returns
				One to unknown	3 months	Hunter returns
Totals		409	16			

farm reared and 25 were wild birds. As determined from differential markings, there was no mixing of the two groups. All the game farm birds were seen at the release site, and the wild stock was observed two and one-half miles distant. Local residents reported chukars eight miles from the release site, but markings were not noticed.

Again in November, 1955, a check on this release resulted in the counting of 24 chukars near the release site. Of these, 16 were wild-trapped birds, as distinguished by markings. Only four birds were unbanded and were assumed to be wild-hatched, and the other four were banded but markings could not be accurately determined. None of the birds could be classified as game farm chukars liberated with the wild-trapped birds.

In 1955, 180 game farm and 30 wild chukars were dropped from an airplane in the Santa Rosa Mountains in Riverside County. On September 21, 1955, 185 wild chukars were dropped from the Department's twin-engined Beechcraft near Mercy Hot Springs in Merced County. The chukars were dropped from an altitude of 200 to 300 feet above the ground at an airspeed of 100 miles per hour. The birds were observed to right themselves within a few feet after leaving the aircraft and glide to safe landings, all within a quarter-mile radius of the spring over which they had been dropped. The birds collected into groups within a period of minutes, and large coveys running on the ground could be observed from the air. During June of 1956 approximately 100 juvenile and adult chukars were seen within one-half mile of the drop site.

Trapping and banding was conducted from 1952 to 1955 to determine movements and survival of wild chukars in the Inyo-Mono and Temblor areas. Only 16 of 419 chukars trapped were returned or found. Table 14 presents the numbers of chukars trapped, banded, and liberated at the trapping sites during the study, with the known returns.

Trapping Methods

Trapping was conducted from August through November (after the nesting season) when the birds were coming in to water. Several methods were employed in attempts to catch chukars: by surrounding water sources with traps; by closing off the water and substituting a container of water surrounded with a trap (Figures 13 and 14); by providing both water and bait; and by placing traps near the water and baiting with grain. Several types of traps were used—quail traps; modified clover-leaf traps; and circular traps. The circular type of trap proved to be the most successful.

The circular trap was constructed from 14-gauge, 1-inch x 2-inch welded steel wire, 3 feet high and 33 feet long. The wire was shaped into a circle nine feet in diameter, and covered with fish net. Three pieces of reinforcing steel were driven into the ground along the wire for support. Two funnel entrances, 12 inches wide, six inches high, and 12 inches long, were hog-ringed to the wire on opposite sides of the trap.

Trapping success was higher in the Inyo-Mono area when wheat was used as bait. Trapping over a water source was the most successful in the Temblor area, where the best results were obtained by placing traps over guzzler entrances (Figure 13).

FIGURE 13. Chukar trapping, using water as bait. Pan of water can be seen in middle of trap. *Photograph by H. Harper and B. Harry.*

FIGURE 14. A trap over a guzzler produces excellent results. Both chukars and valley quail are in the trap. Sacks on top of the trap provide shade for the birds, a necessity in hot weather. *Photograph by H. Harper and B. Harry.*

In the Inyo-Mono area in 1955, 655 chukars were trapped in 49 trap days for stocking in experimental areas (Table 15). The cost of trapping for this operation was $1.13 per chukar trapped (Table 16).

TABLE 15

Trapping Success for Three Areas in Inyo-Mono, 1955

Area trapped	Trap days	Number of traps	Chukars per trap day	Total caught
Junction Springs	18	2	20.0	362
Tennessee Springs	22	2 for 5 days 3 for 4 days	11.2	247
East Springs	9	1	5.1	46
Total				655

TABLE 16

Cost of Trapping 655 Chukars for Experimental Stocking Areas in 1955—Inyo-Mono Area

Cost item	Cost
Travel or mileage (2,450 miles at 7 cents a mile)	$171.50
Trap materials (wire, hog rings, steel, net)	35.00
Bait (wheat at 0.0375 cents per lb.)	20.00
Wages and expenses for one man (22 working days)	515.00
Total cost	$741.00
Cost per bird	$1.13

Experimental Stocking Areas

Six areas were selected for stocking with wild-trapped chukars and stocking began in 1953. The transplant areas were selected and evaluated by comparing them with areas in which chukars were already established. The plan was to stock each area with approximately 100 wild chukars a year, depending on availability, for a period of three years. Liberations were made during the fall, immediately after trapping sufficient numbers. One area has received wild birds for four consecutive years, another was first planted in 1955. Table 17 shows the number of chukars stocked in each area.

Subsequent checks of liberations disclosed that chukars remained in all the areas stocked, and that reproduction occurred in the first year after stocking.

The Caliente area was the only stocked area which was included in the open hunting season in 1954 or 1955. It was planned to prohibit chukar hunting in the remaining five areas for five years or until successful establishment was determined.

TABLE 17

Chukar Experimental Stocking Areas in California

Area	County	Year stocked	Number
Panoche Hills	Fresno	1953	73
Panoche Hills	Fresno	1954	98
Panoche Hills	Fresno	1955	114
Panoche Hills	Fresno	1956	59
Griswold Hills	San Benito	1953	22
Griswold Hills	San Benito	1954	197
Mercy Hot Springs	Merced	1955	185
Lower Kern River	Kern	1954	272
Lower Kern River	Kern	1955	61
Lower Kern River	Kern	1956	54
Lower Poso Creek	Kern	1954	149
Lower Poso Creek	Kern	1955	46
Caliente	Kern	1955	247
Caliente	Kern	1956	100
Totals			1,434

HUNTING SEASON RESULTS

A hunting season check was conducted in both study areas during the first open season in 1954. This season was of four-day duration, with a bag limit of four chukars a day and four in possession. The season was from November 20 to November 23, inclusive. Two checking stations were operated for the four-day season in the Inyo-Mono area. Five stations were operated in the Temblor area for the first two days, with field checks only during the remaining two days.

In 1955 a 16-day season was held, with the bag and possession limit remaining the same as in 1954. The 1955 season opened on November 19 and closed on December 4. The 1955 season included slightly more open areas than in 1954. Checking stations were again operated in the study areas in 1955. Two stations were used in the Inyo-Mono area for the first two days, and eight were operated in the Temblor area for the first two days. Field checks were made for the remaining 14 days in both areas.

In 1956, the season opened on November 17 and closed on December 31 in all of the areas included in the 1955 season, excepting Inyo and Mono counties. Here the season closed on December 15. The bag and possession limit remained the same as in 1954 and 1955. Two checking stations were operated in the Temblor area on the opening two days, and none in the Inyo-Mono range during the 1956 season.

Inyo-Mono Area Hunting Season Results

Hunter Success

Hunting success was considerably higher in 1954 than in 1955. In 1954, 0.78 bird per hunter was taken, and in 1955 only 0.15 bird per hunter was taken (Table 18). No bag limits were checked during the 1955 season. Nine limits were checked during the 1954 season (Table 19).

TABLE 18

Hunter Success for Inyo-Mono Area, 1954 and 1955

Year	Day of season	Number hunters	Hours hunted	Kill*	Birds per hunter	Hours per bird
1954	1st	41	109	(23) 30	0.73	4.7
	2d	103	326	(71) 88	0.85	4.6
	3d and 4th	106	248	(62) 78	0.74	4.0
	Totals	250	683	(156) 196	0.78	4.4
1955	1st	110	374	14	0.13	26.7
	2d	71	175	8	0.11	21.8
	3d to 14th	18	86	8	0.44	10.8
	Totals	199	635	30	0.15	21.2

* Numbers in parentheses under "kill" are corrected figures used to calculate "hours per bird" due to incompleteness of some cards as to "hours hunted".

TABLE 19

Numbers of Hunters Bagging 4, 3, 2, 1, and 0 Chukars During the 1954 and 1955 Hunting Seasons

Area	Year	Day of season	Number of hunters bagging				
			4 birds	3 birds	2 birds	1 bird	0 bird
Inyo-Mono	1954	1st	3	0	4	10	24
		2d	5	5	15	23	55
		3d	1	3	4	23	19
		4th	0	0	6	22	28
		Totals	9	8	29	78	126
	1955	1st	0	0	1	12	97
		2d	0	0	0	8	63
		13th-16th	0	2	0	2	14
		Totals	0	2	1	22	174
Temblor	1954	1st	2	5	25	114	631
		2d	1	1	9	40	271
		3d	2	3	6	7	25
		4th	2	1	0	2	1
		Totals	7	10	40	163	928
	1955	1st	5	10	13	80	527
		2d	1	0	6	45	241
		13th-16th	6	5	6	18	14
		Totals	12	15	25	143	782

Residence of Hunters

Hunters were classified by county of residence and placed into three groups: (1) Local (Inyo-Mono); (2) Los Angeles; (3) other counties (Table 20).

TABLE 20

Residence of Hunters Hunting in the Inyo-Mono Area, 1954 and 1955

Year	Number of hunters			Percentage		
	Local	Los Angeles	Other	Local	Los Angeles	Other
1954	150	80	2	65	34	1
1955	141	45	13	71	23	6

Success With Use of Dog

Success of hunters with dogs in 1954 was only slightly higher than that of those hunting without dogs. In 1955, success of both groups was the same (Table 21).

TABLE 21

Success of Hunters With Dogs Compared With Those Without Dogs—Inyo-Mono Area, 1954 and 1955

Year	With dog			Without dog		
	Number hunters	Kill	Birds per hunter	Number hunters	Kill	Birds per hunter
1954	79	63	0.80	133	98	0.74
1955	65	10	0.15	134	20	0.15

Sex and Age of Kill

A higher young: adult ratio was noted in 1954 than in 1955 (Table 22). Young: adult ratios taken by field observations in 1954 were also higher than in 1955. All the birds were aged by bursa measurements and sexed by internal examination.

TABLE 22

Sample of Sex and Age of Kill During 1954 and 1955 Hunting Seasons—Inyo-Mono Area

Year	Young	Adult	Ratio	Male	Female	Ratio
1954	48	46	104 : 100	46	50	100 : 130
1955	9	12	75 : 100	12	8	100 : 67

Temblor Area

Hunter Success

The average take per hunter was slightly higher in 1956 than in 1955 or 1954. In 1956, 0.30 bird per hunter was bagged; in 1955, 0.26; and in 1954, 0.23. Field observations indicated better reproduction in 1955 than in 1954. (No field observation was made during 1956, since the project was closed in December of 1955.) Table 23 presents the

numbers of hunters checked and the kill for three years. During the four-day season in 1954, only five limits of chukars were checked. Twelve limits were checked during the 16-day season in 1955 (Table 19).

TABLE 23

Hunter Success for Temblor Area in 1954, 1955, and 1956

Year	Day of season	Number of hunters	Kill	Birds per hunter
1954	1st	775	174	0.22
	2d	351	65	0.19
	3d and 4th	10	23	2.3
	Totals	1,136	262	0.23
1955	1st	635	157	0.24
	2d	309	54	0.17
	3d to 14th	43	45	1.05
	Totals	987	256	0.26
1956	1st	102	34	0.33
	2d	39	9	0.23
	Totals	141	43	0.30

Young : Adult Ratio

Age ratios were taken for the 1954 and 1956 seasons. The ratio of one young to four adults indicated poor reproduction in 1954. The young : adult ratio in 1956 was 1.6 : 1 (Table 24).

TABLE 24

Age Ratio of Chukars Killed in the 1954 and 1956 Hunting Seasons—Temblor Area

Year	Young	Adult	Ratio
1954	30	120	25 : 100
1956	26	16	160 : 100

Weights

Weights of 40 chukars were taken during 1954, and of 30 in 1955. Whole birds were weighed. The weights were taken in grams and converted to pounds and ounces (Table 25).

TABLE 25

Chukar Weights Taken During 1954 and 1955 Hunting Seasons—Temblor Area

Year	Number	Heaviest	Lightest	Average
1954	40	1 lb. 8 oz.	11 oz.	1 lb. 4 oz.
1955	30	1 lb. 10 oz.	1 lb. 0 oz.	1 lb. 4 oz.

Crippling Loss

Temblor area hunters were questioned regarding crippling loss. At least 40 chukars of the total checked kill were reported to have been crippled and lost, amounting to a crippling loss of 16 percent of the number of chukars bagged.

Success With Use of Dog

Hunters using a dog during the first two days of the season in 1955 had a success ratio of 0.92 bird per hunter, almost four times greater than that of hunters without dogs. According to hunters questioned, the value of a dog for hunting chukars varied from a distinct advantage to no advantage. This probably depended upon the ability of the dog and its training.

It was determined from observations made during the 1955 season that a wide-ranging dog was of little advantage, since the chukars flushed before the hunter could get close enough for a shot. Close-working dogs (20 to 30 yards) were a decided advantage in seeking out the birds and in retrieving downed birds.

Band Returns From the 1954, 1955, and 1956 Hunting Seasons

Of the thousands of game farm and the several hundred wild chukars banded and liberated in California, only one game farm and 18 wild chukar bands were returned during the 1954, 1955, and 1956 seasons (Table 26).

Harvest

No attempt was made to determine the total number of chukars taken in the Inyo-Mono or Temblor areas in 1954 or 1955. However, from field observations both before and after the 1954 and 1955 seasons, the kill of chukars was thought to be less than 10 percent of the preseason population. One indication of a light harvest in the Temblor area was the return of only six bands from 142 wild-trapped chukars that were banded and released at the trapping site in the area in 1955. This return is only slightly more than a 4 percent take of the 142 banded birds. By computation of a Lincoln Index from the band returns and checked kill in the study area of approximately 60,000 acres, the population of chukars was 6,060, and a checked kill of 256 plus a 16 percent crippling loss amounted to only 297 chukars taken or crippled in this area in 1955. Although the sample is small, it indicates the low take of chukars in this area during the 1955 season. The area where the birds were banded probably has a greater hunting effort than any other area in California where chukars are established, and the area is accessible by automobile.

RECOMMENDATIONS FOR MANAGEMENT

Management of chukars at this time is limited to water development, stocking of areas to increase the range, and hunting regulations.

Habitat

From observations on guzzler use in chukar range, those placed on ridges and knolls at the junction of several large canyons receive the most use by chukars. It was noted that guzzlers placed on flats away

TABLE 26

Known Kill of Banded Chukars Taken in the 1954 and 1955 Hunting Seasons for 18 Returns

Year returned	Year banded	Number	Area released	Time interval in field	Distance moved	Remarks
1954	1952	150	Lucerne, San Bernardino County	2 years	?	Game farm chukars
1954	1952	189	Santa Rita Flats, Inyo County	2 years 3 months	33 miles	Wild-trapped chukars released at trap site
1954	1954	45	Barrel Springs, Inyo County	1 month	negative	Wild-trapped chukars
1954	1954	45	Barrel Springs, Inyo County	1 month	negative	Wild-trapped chukars
1955	1953	80	South Fork Kern River, Kern County	2 years 2 months	?	Wild-trapped release
1955	1953	80	South Fork Kern River, Kern County	2 years 2 months	?	Wilh-trapped release
1955	1953	80	South Fork Kern River, Kern County	2 years 2 months	?	Wild-trapped release
1955	1953	80	South Fork Kern River, Kern County	2 years 2 months	?	Wild-trapped release
1955	1955	142	Temblor Range, Kern County	3 months	negative	Wild-trapped chukars released at trap site
1955	1955	142	Temblor Range, Kern County	3 months	6-8 miles	Wild-trapped chukars released at trap site
1955	1955	142	Temblor Range, Kern County	3 months	4 miles	Wild-trapped chukars released at trap site
1955	1955	142	Temblor Range, Kern County	3 months	?	Wild-trapped chukars released at trap site
1955	1955	142	Temblor Range, Kern County	3 months	negative	Wild-trapped chukars released at trap site
1955	1955	142	Temblo Range, Kern County	3 months	20 miles	Wild-trapped chukars released at trap site
1956	1955	142	Temblor Range, Kern County	1 year 3 months	negative	Wild-trapped chukars released at trap site
1956	1955	247	Caliente release area, Kern County	1 year 3 months	negative	Wild-trapped release
1956	1955	247	Caliente release area, Kern County	1 year 3 months	negative	Wild-trapped release
1956	1956	100	Caliente release area, Kern County	3 months	negative	Wild-trapped release

TABLE 27

Chukar and Wildlife Use of Guzzlers and Water Troughs in the Temblor Area, 1955

Date of count	Location and type	Placement	Wildlife				
			Chukars	Valley quail	Doves	Cottontails	Jackrabbits
July 8	Catfish No. 76 guzzler	Junction of two large canyons	15	0	3	2	1
July 8	Catfish No. 77 guzzler	Bottom of canyon	0	11	2	3	10
July 11	Burma Road trough	On ridge between two large canyons	55	3	71	0	5
July 12	Middle quality guzzler	On ridge between two small canyons	78	21	1	2	1
July 12	Upper quality guzzler	On ridge overlooking two large canyons	107	43	3	2	1
July 13	Poleline guzzler	On flat near shallow canyon	9	17	12	3	14
July 13	Maricopa No. 73 guzzler	On large flat at mouth of canyon	0	0	0	0	0

from canyons and hills, even where cover is plentiful, receive little use by game species. Six guzzlers and one water trough were censused during July in the Temblor range in 1955 to determine wildlife usage. Censusing time was from sunrise to 9 a.m. The units that received the greatest use were those installed below the crest of the range and on small benches overlooking large canyons (Table 27).

In areas where large populations of chukars and valley quail were using guzzlers, it was found that water in single units was exhausted before the summer was over. Double units or the large metal tank (holding approximately 1,200 gallons) that development crews are now installing in Region IV should be provided in such areas.

Ramps placed in stock watering troughs and tanks in the Temblor range have reduced the loss of chukars by drowning. Ramps are needed in all tanks and troughs located in chukar range.

Stocking

Future plantings of chukars can be obtained from wild-trapped stock. In counties south and east of the Tehachapi Mountains, almost all areas that have suitable or marginal habitat for chukars have been stocked. Further plantings in this area should be limited or abandoned.

The six experimental stocking areas in Kern, Merced, San Benito, and Fresno counties should continue to receive plants.

Hunting Season Regulations

Three hunting season checks indicate that chukars are not in any danger of being overharvested when the season occurs during the regular quail season. A hunting season to conform with the quail season in the county is recommended, with a bag limit of six chukars per day.

It is doubtful that there is any danger of overshooting, since the chukar inhabits the most rugged semidesert type mountain terrain of the State.

It is recommended that the counties bordering the State of Nevada north of Lake Tahoe be opened to chukar hunting during the regular quail season.

SUMMARY

From 1932 through 1955, 52,184 game farm chukars were released in all except four of California's 58 counties. As a result of these releases, chukars have become established in the desert and semiarid regions throughout California, where yearly precipitation seldom exceeds 10 inches.

Two study areas were selected to study the life history and management of the chukar. One area was in the Great Basin region of Inyo and Mono counties; the other was in the eastern range of the Coast Range Mountains in Kern and San Luis Obispo counties. Annual precipitation in both these areas seldom exceeds seven inches.

Chukars pair during February and early March and bring off broods from late April through August. The peak of hatch occurs from the middle of May to the first week in June.

The largest clutch size in nests found contained 16 eggs. The largest brood observed had 17 chicks. The average clutch size is 11 or 12 eggs.

It is believed that accurate counts of brood sizes are unreliable after three weeks of age, due to the mixing of broods. Probably a more accurate method of determining yearly reproduction would be the taking of young: adult ratios during July and August.

The so-called "wet" years in the desert and semidesert areas appear to be more favorable to chukar reproduction than any other factor, especially when precipitation occurs during the late winter and spring months.

Predation on young or adult chukars was seldom observed. It is believed that predation has little effect on chukar numbers except for destruction of nests by ravens and ground predators. Losses to nests through farming practices is low because most of the chukar populations are not found near agricultural areas.

During the hot, dry summer months chukars are seldom observed more than one mile from water. After the first cool days and the first rains in early fall, chukars disperse from their summer haunts near water and forage into range not frequented during the summer.

Chukars have been observed from below sea level in Death Valley to 12,000 feet in the White Mountains and in the Sierra Nevada. Snow at the higher elevations tends to move the birds to lower elevations where the ground seldom is covered with snow.

Crops from 87 chukars in the Inyo-Mono area were examined and 91 food items were found, with Russian thistle heading the list. Grasses ranked second in the chukars' diet in that area. In 42 crops from chukars in the Temblor area, 52 separate food items were found, with red-stemmed filaree first and fiddle-neck second in importance.

Competition with native game species was not found to be serious during the study.

Crop damage by chukars was reported occasionally, but only from localized areas where small ranches and farms adjoined chukar range.

Only four chukars of the thousands of wild birds handled during the study appeared to be diseased, but no accurate diagnoses could be made of these.

From 1953 through 1956, 2,899 wild chukars were trapped and released in areas without established chukar populations. In addition, 419 chukars were trapped, banded, and released at the trapping site to determine movements and obtain hunting season returns.

Successful plants were made in remote areas by free-fall dropping of chukars from an airplane.

Trapping using water and grain as bait was conducted with variable success. Several types of traps were used, with the circular trap proving to be the easiest to construct, the least expensive, and the most successful.

The first hunting season was opened in 1954, when a four-day season was held with a daily bag limit of four birds. In 1955 a 16-day open season was held, with the same bag limit remaining in effect. A 45-day season was held in 1956, in the areas open in 1955, except Inyo and Mono counties, where the season was 29 days. Hunter success was low during 1954 and 1955. The low average is a result of the type of terrain the chukar inhabits, not a result of low chukar numbers.

It is believed that less than 10 percent of the total chukar population was harvested during the hunting seasons.

Of 142 wild chukars banded in 1955 and released in one of the most heavily hunted areas, only six were returned during the 1955 season.

Management of the chukar is primarily a matter of making further water developments, stocking new areas with wild-trapped birds, and regulating the harvest.

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DEER SURVIVAL AND RANGE FORAGE TRENDS ON EASTERN CALIFORNIA WINTER RANGES[1]

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INTRODUCTION

The complete censusing of deer in the wild is a difficult and often impossible undertaking. Most game departments attempt to manage deer herds on the basis of trends in population, as indicated by systematic track counts, composition of the kill, total harvest, pellet group counts, percentage utilization of forage, range condition, or other indices of animal numbers.

As a result of a series of investigations made by the Department of Fish and Game and cooperators, information on range condition, forage production, forage utilization, and fawn survival has been gathered from seven winter deer ranges in eastern California. These data have been analyzed. The findings indicate that in the eastern portion of the State, an area subject to Great Basin influences, there has been a similarity in trend in fawn survival, as well as in range elements on ranges scattered throughout the region. The findings indicate that dominant region-wide trends may be determined from the sampling of scattered ranges, an important feature where time and manpower are limited.

DESCRIPTION OF AREAS

The seven winter deer ranges from which findings are reported are (1) Devils Garden interstate range in Modoc County, (2) Lassen-Washoe interstate range in Lassen County, California, and Washoe County, Nevada, (3) Verdi range in Sierra County, California, and Washoe County, Nevada, (4) West Walker range in Mono County, California, and Douglas County, Nevada, and (5) Buttermilk, (6) Goodale Creek, and (7) Tunawee Canyon ranges in Inyo County (Figure 1).

All of these ranges support Great Basin sagebrush, juniper or piñon woodland, and yellow pine forest vegetation types. The juniper woodland of the more northerly ranges shades into piñon woodland in the south. The Buttermilk, Goodale Creek, and Tunawee Canyon winter deer ranges border on xerophytic vegetation (mostly desert shrub) at their lower margins. This is especially true of the Goodale Creek and Tunawee Canyon ranges.

[1] Submitted for publication December, 1956. This paper is a contribution from Federal Aid in Wildlife Restoration Project California W-51-R, "Big Game Studies".

FIGURE 1. Map of California, showing the location of the deer herd study areas. *Drawing by Cliffa Corson.*

Table 1 gives average annual rainfall data for stations adjacent to the study areas. It may be seen that precipitation tends to decrease from north to south.

TABLE 1

Precipitation Data for Stations Adjacent to Study Areas—Annual Average

Alturas, Modoc County (Devils Garden)	12.53 inches
Doyle, Lassen County (Lassen-Washoe)	9.55 inches
Reno, Nevada (Verdi)	7.73 inches
Coleville (Shields Ranch), Mono County (West Walker)	11.41 inches
Bishop, Inyo County (Buttermilk)	5.38 inches
Independence, Inyo County (Goodale Creek)	4.93 inches
Haiwee, Inyo County (Tunawee Canyon)	4.90 inches

TABLE 2

The Rankings of the Several Study Areas in Relation to Listed Range Elements

	Devils Garden	Lassen -Washoe	Verdi	West Walker	Buttermilk	Goodale Creek	Tunawee Canyon
Herbaceous cover—most to least	1	3	2	4	5	7	6
Bitterbrush cover—most to least	3	4	2	5	1	7	6
Vigor of leader growth—most to least	1	3	2	4	5	5	--
Shrubs not hedged—most to least	3	6	2	1	5	4	7
Decadent shrubs present—least to most	3	6	1	2	4	5	7
Shrubs heavily hedged—least to most	2	7	3	4	5	1	6
Degree of utilization by deer—least to most	3	2	1	4	5	4	6
Percentage overbrowsing by deer—least to most	1	3	2	7	5	4	6
Dead browse cover—least to most	1	3	2	4	6	7	5

Although all seven ranges support similar vegetation types, there are considerable differences between them in composition of ground cover, as well as in condition of browse stands. For instance, 18.7 percent of the Devils Garden range is covered by herbaceous vegetation, but this class of vegetation covers only 3.4 percent of the Goodale Creek range. The Devils Garden ranks third among the seven ranges in percentage of bitterbrush cover, percentage of bitterbrush shrubs classed as decadent, has the greatest percentage of bitterbrush plants classed as young, and the least coverage by dead browses. At the other extreme, the Tunawee Canyon range ranks fifth, sixth, or seventh in all of these categories.

The ranking of the several areas in relation to listed range elements is given in Table 2. Comparisons of the actual findings are made in Tables A-1 and A-2 of the Appendix.

A more detailed description of several of the deer winter ranges is given by Leach (1956).

METHODS

The Fawn Survival Record

Fawn survival has been measured on eastern California deer ranges by means of doe: fawn ratios secured from herd composition sample counts. Counts were made during the rutting season in November and December and again at the end of the winter period, usually in April. During the first counts the animals were classed as bucks (of various antler classes), does, or fawns. These counts gave ratios which were indicative of the number of fawns surviving from birth to the start of the winter period.

The second counts, made just before or at the time deer were leaving for summer ranges, gave ratios which were indicative of the number of fawns surviving the winter to become yearlings. In the spring counts, the animals were classified as either adults or fawns (buck deer are difficult to distinguish from doe deer at this time because they lack antlers). It was assumed that the same proportions of bucks to does existed in the spring as were present the previous fall. The adult: fawn ratios were converted to doe: fawn ratios by means of fall percentages.

Doe: fawn ratios are not ideal indices of survival because of variations in the percentage of non-bearing yearlings and of light-bearing two-year old animals in the doe herd, and the degree of loss in the doe herd itself between birth of fawns and the time when the counts are made. It should be pointed out that the doe: fawn ratios given in Table A-3 of the Appendix are to some degree influenced by kills of antlerless animals from the Devils Garden herd during hunting seasons in Oregon since 1950, and in California during 1950, 1951, and 1955; from the Lassen-Washoe herd during hunting seasons since 1949 in Nevada, and during 1951 and 1955 in California. The other deer herds were subjected to buck hunting only until 1955, when special antlerless seasons were allowed for the West Walker and Buttermilk deer herds.

Despite the limitations of the doe: fawn ratio as a survival index, such ratios do provide a coarse measure of fawn survival and are useful

for comparisons of mortality between ranges, particularly where the ranges are subjected more or less to the same general influences.

The Range Record

Forage surveys have been made in eastern California winter deer ranges by means of permanent sample plots located on winter concentration (key) areas, except for the Tunawee Canyon range, where temporary plots were used. Utilization was estimated on a percentage leader length removal basis for bitterbrush (*Purshia tridentata* and *P. glandulosa*) and by percentage volume removal for sagebrush (*Artemisia tridentata*), as described by Dasmann and Blaisdell (1954). Usually one check was made in the fall to determine the percentage used principally by livestock during the summer grazing season, and a second check in the spring to determine total use by all classes of animals during the biotic year. By subtracting the summer use and rodent use (where it occurred) from the total, the percentage of the current growth used principally by deer was computed.

Bitterbrush is considered the indicator browse species on all of the seven winter ranges investigated. Utilization of this browse is generally so much heavier than that of other important browse species that there is little danger of damage through over-browsing of other species, so long as bitterbrush utilization is kept within allowable limits. Food habits studies have shown that sagebrush usually furnishes a greater volume of browse forage to deer over the winter period. However, sagebrush is more plentiful and percentage utilization of this browse is usually considerably lighter than that of bitterbrush.

Utilization findings for bitterbrush and sagebrush are presented in Tables A-4 and A-5 of the Appendix.

The percentage of plots on which bitterbrush utilization averaged 60 percent or more was computed for each range from the forage utilization records. Such percentages may be used as indices of the proportion of the area supporting bitterbrush on which this species has been used too heavily. These heavy use percentages for bitterbrush will be found in Table A-6 of the Appendix.

During the fall utilization surveys, a record was made of length of the primary leaders found on each bitterbrush shrub checked, and an average was determined for each plot. From these, an average leader length for the range was computed, to serve as a growth index for the year. These growth indices may be used as indicators of forage production. When the growth index is multiplied by percentage utilization, the product will be the inches of primary leader growth utilized. The growth indices for bitterbrush, together with computed inches of twigs taken by deer and by all classes of animals, are given by year in Table A-7 of the Appendix.

Pellet group counts were made each spring on one-tenth-acre strip plots (6 feet wide and 11 chains long) located at the forage plot sites. It was the aim to count only droppings of the season, which were distinguished from older droppings by color and shine. The group was not tallied unless more than half the droppings in a group were located on the strip. The results of the counts are given in Table A-8 of the Appendix.

FINDINGS

Fawn Survival

1951-52

The year 1951 was a good browse growth year, as will be seen from Table A-7 of the Appendix. Bitterbrush leader growth averaged 4.5 inches for the three ranges for which data are available, in contrast with 3.2 inches for the same ranges in 1950. Probably in response to an improved food condition, the summer survival of fawns in 1951 was high. The average fall ratio from six deer ranges was 73 fawns per 100 does. Four of the five herds for which comparable data are available showed a summer survival higher than that of the previous year; the fifth herd showed no change. These animals were to be subjected to heavy mortality during the winter which followed.

The winter of 1951-52 was unusually severe in California. Heavy snows fell in late December and continued intermittently throughout the season. In many instances deep snows forced deer into marginal wintering areas at lower elevations, where browse was either scarce or made up of species of sub-standard food value. In eastern California there was a severe loss of animals throughout the region. All the herds suffered, as indicated in Table A-3 of the Appendix. By the spring of 1952 the doe: fawn ratio had fallen from an average of 73 to an average of 32 fawns per 100 does. The actual mortality was somewhat greater than the ratios indicate, since the ratios do not reflect the considerable loss of older animals. This was by far the highest average decrease in doe: fawn ratios occurring during the period for which records are available.

1952-53

The winter of 1951-52 was followed by what appeared to be good all-round conditions for deer. Owing to the abundant moisture of the previous winter, the growth of browse was exceptional during 1952. There was also an abundance of herbaceous vegetation. Surveys showed that the current leader growth of bitterbrush averaged 5.1 inches, the highest recorded during the investigation. These good conditions were not reflected in summer fawn survival, however. The fall counts yielded an average ratio of 52 fawns per 100 does. Five of the six herds for which data are available showed a summer survival lower than that of the previous year; the sixth showed an increase of one fawn per 100 does. Although the 1951 breeding season took place before severe winter weather occurred, it appears that the stresses to which the breeding does were subsequently subjected left the survivors in poor physical condition. Irrespective of whether the fawns were lost before or after birth, the average summer survival as indicated by the doe: fawn ratios was the second lowest encountered during the past six years.

Although survival of fawns until fall was low, there was little subsequent loss during the mild, open winter of 1952-53. The spring counts indicated an average ratio of 46 fawns per 100 does returning to summer ranges, which was well over the ratio of 32 per 100 the previous spring. The heaviest loss occurred on the Tunawee Canyon range, where the ratio dropped from 46 to 29 fawns per 100 does. At the other extreme, on the Lassen-Washoe range the over-winter drop in ratio was

only from 65 to 64. All of the five herds for which data are available showed a winter survival higher than that of the previous year.

1953-54

Low fawn production in 1952 was followed in 1953 by the highest production recorded in the investigation. The deer herds, having experienced the excellent forage year of 1952 and the mild, open winter of 1952-53, passed through a fair browse year in 1953. Bitterbrush leader growth was computed at an average of 3.1 inches for the six ranges surveyed. The herds came onto the winter ranges in the fall of 1953 with a crop of fawns that yielded the highest ratios encountered during the seven-year record period. Five of the six herds for which data are available showed a summer survival higher than that of the previous year; the other showed a decline of two fawns per 100 does. The over-all average of 76 fawns per 100 does included ratios of 96 fawns per 100 does on the Devils Garden range and 99 fawns per 100 does on the Verdi range.

Winter survival of the fawns of 1953 did not fulfill the promise of the high fall ratios. Two years had passed since the severe die-off of the winter of 1951-52. If the track count record from the Devils Garden range is at all indicative of region-wide trends, the two fawning seasons resulted in replacement of the animals lost during the hard winter in most, if not all, of the deer herds. The net counts of Devils Garden deer moving into Oregon summer range for the past six years are as follows: 1951—17,570; 1952—10,547; 1953—11,601; 1954—17,615; 1955—17,170; 1956—12,144.

Although the winter of 1953-54 was similar to the previous one in being mild and open, heavier losses among fawns than those which occurred during the winter of 1952-53 were experienced. Perhaps because deer herd populations had once more peaked beyond the carrying capacities of the various ranges, the average ratio fell from 76 fawns per 100 does in the fall to 52 fawns per 100 does in the spring. However, in spite of this loss the winter survival of 1953-54 was the highest recorded during the five years for which spring records are available. Three of the five herds for which data are available showed higher spring survival than that of the previous year; one herd showed no change, and the other showed a decline of 7 fawns per 100 does.

1954-55

Mild, open winters are favorable to fawn survival, but precipitation shortages affect deer adversely when they result in poor forage production. The growth of browse during 1954 was abnormally low. Current bitterbrush leaders averaged only 2.7 inches in length for the six ranges on which they were measured. Summer fawn survival in 1954 fell below that of 1953 on all but the two most southerly deer ranges, for the seven herds for which comparative data are available. The average ratio was 67 fawns per 100 does, compared with 76 fawns per 100 does the previous year.

The pattern of mortality was maintained through the winter of 1954-55. Although snowfalls were light, the temperatures were below freezing for sustained periods. Freezing weather inhibited the growth of herbaceous forage and browse became the mainstay of the deer diet

throughout the region. Toward the end of the winter, deer were commonly reported to be in poor condition. When the spring counts were made it was found that the average ratio was 48 fawns per 100 does, a drop of 19 from the previous fall. All five of the herds for which data are available showed a winter survival less than that of the previous year.

1955-56

It was thought at the time that the forage production of 1954 had hit bottom, but the condition worsened in 1955, when very poor growing conditions resulted in even lower production of both herbaceous and browse forage. Bitterbrush leader growth declined to an average of 2.2 inches, one-half inch less than that of the year before. Summer fawn survival was poor, as might have been predicted from past records. It fell below the survival of the previous year in all six of the herds for which data are available. The average ratio was 50 fawns per 100 does, the lowest average summer survival encountered during the six-year investigation.

The weather was not unusually severe; however, fawn losses continued during the winter of 1955-56. Although periods of freezing weather occurred on some ranges, the occurrence of heavy rains melted snow-packs, allowing wide distribution of deer at elevations above those used normally during that season. Winter survival fell in all six of the deer herds. The average ratio was 35 fawns per 100 does, a drop of 15 fawns per 100 does from the previous fall. This ratio was only 3 fawns per 100 does better than that found in the spring of 1952, following a winter which produced the lowest survival on record.

DISCUSSION

The rather pronounced similarity in year-to-year variation in fawn survival in deer herds in eastern California may be seen in Table 3. The survival of fawns has gone down, and up, and down again in deer herds throughout the region, perhaps in response to the effect of weather on food abundance. The indications are that once deer populations exceed optimum levels (i.e., levels at which the animals have all they need in order to flourish), fawn survival becomes closely respondent to the secondary effects of weather. Such populations are subject not only to direct weather stresses, but are immediately affected by fluctuations in maximum carrying capacities which result from increased and decreased forage production.

It is pointed out that even though a fawn survival rated as relatively high on one range would be rated as low on another range, the highs, intermediates, and lows of individual ranges coincide to a significant extent throughout the region.

The findings indicate that the trend in fawn survival for any one year in eastern California may be determined from sampling a relatively few deer herds. The probabilities are strong that the trend determined from such a sample will hold true for the entire region. This is borne out by a comparison of composition ratios from other deer herds in eastern California and adjoining areas. These were compiled and compared, as summarized in Table A-9 of the Appendix.

TABLE 3

Trends on Selected Great Basin Winter Ranges

	Winter period	Devils Garden	Lassen-Washoe	Verdi	West Walker	Buttermilk	Goodale Creek	Tunawee Canyon	Agreement
Fawn survival	1952-53		+		+	+	+	+	5 out of 5
	1953-54		+		+	0	—	+	3 out of 5
	1954-55		—		—	—	—	—	5 out of 5
	1955-56	—	—		—	—	—	—	6 out of 6
Annual growth of bitterbrush leaders	1951-52	+	+			+			3 out of 3
	1952-53	+	—			+			2 out of 3
	1953-54	—	+	—	—	—	—		5 out of 6
	1954-55	—	—	—	—	+	+		4 out of 6
	1955-56	—	0	0	—	—	—		4 out of 6
Over-browsing (based on percentage of plots showing 60 percent or more use)	1950-51	—				—			3 out of 3
	1951-52	—	—			—	—	—	5 out of 5
	1952-53	—	—			—	—	—	5 out of 5
	1953-54	+	+	—	—	+	+	+	5 out of 7
	1954-55	+	+	+	+	+	—	—	5 out of 7
	1955-56	—	—	—	—	+	+	—	5 out of 7
Number of pellet groups per acre	1950-51	+	+			+			3 out of 3
	1951-52	—	+			—	—		2 out of 3
	1952-53	—	—		—	—	—	+	5 out of 6
	1953-54	+	—	—	—	+	—	—	5 out of 7
	1954-55	—	+	+	+	+	+	—	5 out of 7
	1955-56	—	—	—	+	—	—	—	6 out of 7

Legend:
+ = greater than the year previous.
— = less than the year previous.
0 = no change from the year previous.

It will be seen from this table that fawn survival trends in other eastern California deer herds were the same in most cases as the trends indicated from the samples. Also of considerable interest is the fact that trends in deer herds in adjoining portions of the State showed considerable similarity.

The relationship of forage production to fawn survival is brought out in Table 4.

TABLE 4
Relationship of Forage Production to Fawn Survival

Year	Average leader growth, inches	Fawns per 100 does		Probable status of deer population
		Fall	Spring	
1951-52	4.5	73	32	Above optimum in a good forage year, but a hard winter.
1952-53	5.1	52	46	Heavy winter reduces population below optimum level, but leaves breeders in weakened condition.
1953-54	3.1	76	52	Good fall survival, but herd passes optimum level, and winter losses become heavy.
1954-55	2.7	67	48	Above optimum level in poor forage year.
1955-56	2.2	50	35	Above optimum level in very poor forage year.

It should be emphasized that this fawn survival record indicates that any attempt to stockpile deer, once populations exceed optimum levels, will lead only to waste. It is probable that an increased harvest during 1953 and 1954, by reducing deer pressure for the things they need on the ranges in eastern California, would have enhanced chances of survival for the remaining animals and resulted in wiser use and less preventable waste.

Growth Indices

Where all the other factors remain constant, percentage utilization of browse by deer will fluctuate with forage abundance. For this reason it is important that year-to-year changes in percentage utilization be evaluated in the light of variations in forage production. It will be seen from Table A-7 of the Appendix that during the period of investigation there was considerable year-to-year variation in average bitterbrush leader growth throughout the region.

As was pointed out in the section on fawn survival, bitterbrush leader growth increased markedly during 1951-52 over the previous year, increased still more during 1952-53 (in response no doubt to better moisture conditions), and has fallen off rather sharply since. Growth for the southern half of the region averaged only 2.4 inches, compared with 3.8 inches for the northern half for 1953-54. The slight increase in growth on the southern ranges during 1954-55 brought the average there (2.6 inches) more in line with the decreased average for the northern ranges (2.8 inches). The average of 2.2 inches of growth produced in 1955-56 was the lowest region-wide production recorded during the investigation.

Like fawn survival, bitterbrush growth tended to be better on some ranges than on others. But as could be expected throughout a region subject to the same general weather influences, the upward and downward trends in production in the different areas exhibited trend similarity during the five years for which records are available. This is shown in Table 3.

Actual variations in production were of small magnitude, although there were four instances in which trend in production on individual ranges was the reverse of that dominant for the region, and two others in which no change from the previous year occurred. The indications are that it is entirely possible to evaluate region-wide conditions from the results of scattered range samples.

Bitterbrush Utilization

An examination of the year-to-year fluctuations in percentage utilization of bitterbrush by deer, shown in Table A-4, reveals general similarity in trend throughout eastern California, but exceptions are common on the individual ranges. This is understandable when one considers the number of influences, other than deer numbers, which affect this factor. For instance, the very low utilization recorded on several occasions for the Tunawee Canyon range resulted from poor growth, not from decreased deer browsing pressure. Bitterbrush leader growth was too short to be available for browsing, so percentage utilization fell off accordingly. On the other hand, the relatively light bitterbrush utilization on three out of five ranges during the hard winter of 1951-52 (a time when deer were concentrated and when one might expect a sharp increase in browsing pressure) resulted from two factors: (1) good growth allowed removal of a greater volume of forage without increasing utilization percentage-wise over that of the previous year, and (2) unusually heavy snows pushed deer below the bitterbrush zone on some ranges for varying periods. Again, during open winters deer sometimes remain scattered outside the usual concentration areas, thus lowering percentage utilization on key portions of the range. A comparison is made in Table 5 between percentage utilization of bitterbrush with average leader growth and with use indices (i.e., average inches of bitterbrush growth consumed by deer).

TABLE 5

Percentage Utilization of Bitterbrush Compared With Bitterbrush Leader Growth

Year	*Utilization (percentage)*	*Use index (inches)*	*Leader length (inches)*
1949-50	41	1.2	3.4
1950-51	43	1.1	3.2
1951-52	31	1.3	4.5
1952-53	29	1.3	5.1
1953-54	35	0.9	3.1
1954-55	42	1.1	2.7
1955-56	34	0.8	2.2

In contrast with bitterbrush, percentage utilization of sagebrush during the severe winter of 1951-52 was as high, or higher, than any recorded to that time, as may be seen from Table A-5 of the Appendix. This is understandable in view of the much wider elevational distribution of sagebrush on all the ranges surveyed.

Findings reported in a prior article indicated an inverse relationship between percentage utilization of bitterbrush by deer and fawn survival on the Lassen-Washoe winter deer range (Dasmann and Blaisdell, 1954). The records from the other eastern California deer ranges were examined to determine if such a close relationship exists throughout eastern California. It was found that no close year-by-year relationship has occurred on the other ranges for which data are available, with the exception of an exaggerated relationship on the Goodale Creek range. The records from several of these ranges are distorted by the conditions peculiar to the winter of 1951-52, when heavy fawn losses occurred in the face of light bitterbrush utilization. However, even when the findings for that winter are thrown out, there are too many exceptions to indicate anything but a loose relationship between fawn survival and percentage utilization, except for the Lassen-Washoe range, where the above-mentioned close relationship was maintained.

Percentage of Over-browsing

The percentage of plots (or area) over-browsed during any year is a product not only of utilization, but of distribution of animals on the range. For instance, if utilization averaged 60 percent on one-third of the plots on an area and no use occurred on the balance, an average use of 20 percent would result in the over-browsing of one-third of the area. On the other hand, if utilization was distributed evenly over the range, an average use of 20 percent would result in none of the area being over-browsed. Because of this, the trend in percentage of plots over-browsed may be at variance with the trend in utilization.

Region-wide averages for percentage of over-browsing as a result of deer use are given for the seven years on record, as follows: 1949-50, 64 percent; 1950-51, 45 percent; 1951-52, 27 percent; 1952-53, 19 percent; 1953-54, 40 percent; 1954-55, 44 percent; 1955-56, 34 percent.

The region-wide average for the winter of 1951-52 was 27 percent, a decline from 45 percent for the winter previous. This decrease in percentage of plots over-browsed during the severe winter occurred on all five ranges for which records are available. This indicates that browsing was less concentrated area-wide than for previous years, probably because heavy snows forced deer off bitterbrush zones before distributional concentrations occurred and because of the increase of available forage resulting from the good growth of 1951.

The percentages of over-browsing attributed to wintering deer are, of course, affected by the degree of utilization by livestock the previous summer. For instance, if livestock use leaves a large percentage of the shrubs in the 40-55 percent use class, an additional use by deer of only 5-20 percent results in such shrubs being included in the percentage of over-browsing due to deer category. On the seven ranges investigated, this factor could be of importance on three (Lassen-Washoe and, to a lesser extent, the Verdi and West Walker). An examination of Table A-6 of the Appendix, however, does not indicate that this factor is of great significance, although it does affect the percentages.

Percentage of over-browsing on the several ranges exhibited rather close trend similarity, as may be seen from Table 3.

It appears that the relationship is close enough to allow region-wide evaluation of the trend in over-browsing through use of scattered range samples.

Pellet Counts

The number of pellet groups on an area is a product of the number of deer and length of period of use. In addition, there may be seasonal variations in defecation rates where marked changes in diet occur, as reported by Dasmann and Taber (1955). Pellet group counts may be used directly as indices of trend in deer pressure on the range. The findings from eastern California help to explain the deer survival and forage utilization records for individual ranges.

Region-wide pellet count averages for the past seven years are listed as follows, showing the number of groups per acre: 1949-50, 299; 1950-51, 365; 1951-52, 372; 1952-53, 295; 1953-54, 287; 1954-55, 367; 1955-56, 286.

It will be seen from Table A-8 of the Appendix that although the region-wide average for the winter of 1951-52 was the highest recorded during the investigation of the three ranges for which data are available for both 1950-51 and 1951-52, there was actually a decrease in count on two ranges (Devils Garden and Buttermilk), probably due to deer being forced off key areas into marginal winter range, and as the result of heavy mortalities during the period of use. The records indicate that this may have been true for the Tunawee Canyon and Verdi ranges, which yielded high counts in 1952-53, a year when pellet counts were low for all other ranges.

The region-wide pellet count averages are consistent with the range record and the record of deer survival. The count was highest region-wide during the severe winter of 1951-52; it fell off in 1952-53 with the decreased deer population; it fell still lower in 1953-54 as a result of a mild, open winter which allowed deer to remain widely scattered on most ranges; it showed a sharp increase when the adverse winter conditions of 1954-55 concentrated a high deer population on key areas of the winter ranges; and it fell off in the open winter of 1955-56 to a level comparable to that of the second year previous.

Year to year trends in pellet counts on the various winter ranges in the region exhibited rather close similarity (Table 3). Here again it appears possible to judge region-wide trends in deer pressure on winter concentration areas from the result of scattered range samples.

SUMMARY AND CONCLUSIONS

Information on range condition, forage production, forage utilization, deer pressure, and fawn survival has been gathered from seven winter deer ranges scattered throughout eastern California. The region is subject to Great Basin influences. The findings indicate a similarity in year-to-year trends in (1) fawn survival, (2) current leader growth of bitterbrush, (3) percentage over-browsing of bitterbrush by deer, and (4) degree of deer pressure on winter concentration areas as indicated by pellet counts. It appears possible to determine region-wide trends in these elements from the sampling of scattered ranges, an important feature where time and man-power are limited.

While fawn survival is much better on some ranges than on others, the highs, intermediates, and lows appear to coincide to a significant extent on the various ranges. The indications are that, once deer populations exceed optimum levels (i.e., levels at which the animals have all they need in order to flourish), fawn survival becomes closely respondent to the secondary effects of weather. Such populations are immediately affected by fluctuations in maximum carrying capacity that result from increased or decreased forage production. Hence, survival is apt to be higher in good growth years and lower in poor growth years, except in that there may be a one-year lag in increased survival where breeding animals have been subjected to the stresses of weather and starvation during a hard winter.

While general range condition (i.e., kind, quantity, and condition of forage and soil) no doubt plays a major role in determining the average level of survival on individual deer ranges (viz., 56 fawns per 100 does on the Lassen-Washoe compared with 30 in the Goodale), the relation of annual precipitation and abundance or scarcity of herbaceous vegetation is worthy of more attention.

Of the various range factors considered here, it is obvious that neither percentage utilization of key forages nor percentage of overbrowsing may be considered as reliable indicators of year-to-year trends in populations, since they are affected by other influences. Inches of leader growth browsed and pellet counts are good indices providing the entire area which deer occupy, in mild as well as in heavy winters, is sampled. The information derived from such surveys is chiefly valuable as a record of actual year-to-year deer pressure on the areas surveyed. However, long-term increases or decreases in deer populations may be indicated by a comparison of results of surveys made over a series of years.

SOURCES OF DATA

The findings from the Devils Garden range are taken principally from the progress reports of the Devils Garden Deer Herd Committee and from the mimeographed reports of Trevenen Wright and Edward R. Schneegas, Department employees who successively worked in this area.

The Lassen-Washoe deer herd management plan, a mimeographed report prepared by the Lassen-Washoe Interstate Deer Herd Committee, is the source of material from this winter range. Some additional facts were derived from the reports of Robert W. Lassen and James Blaisdell, who successively carried on the area investigation for the Department.

The Verdi range data were taken from reports of Russell Henry and Donald Beauchamp, Department employees who have carried on the work in that area.

The Carson-Walker Interstate Deer Herd Committee has issued mimeographed reports of findings on the West Walker and other adjacent deer ranges. These are the source of some of the West Walker material. The balance has been drawn from reports of Gene Gerdes, who is making the investigation for the Department.

Data from the Buttermilk, Goodale Creek, and Tunawee Canyon ranges have been drawn principally from a mimeographed report, "The Inyo-Sierra Deer Herds", prepared by Fred L. Jones. He carried on the investigation in that area until 1953. Information from this report has been supplemented from the reports of Gene Gerdes, who is currently doing deer work in that part of the State.

Range investigations were initiated and both range and deer studies were directed by the senior author from 1951 until 1953, at which time the junior author took over general direction of the investigations. Dr. A. M. Schultz of the University of California School of Forestry made the statistical analysis of the data.

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APPENDIX

TABLE A-1

Comparison of Ground Cover Composition

Item	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon
Number of sample plots	204	234	33	54	62	33	19
Type of plot*	LI	LP	LP	LP	LP	LP	LP
Bare ground	29.2	32.3	18.0	38.6	40.7	41.5	49.3
Rock	5.5	--	7.2	10.0	6.9	11.3	9.2
Litter	29.8	28.9	29.0	12.6	9.7	11.1	8.1
Dead browse plants	3.6	6.7	4.2	9.6	12.4	15.3	11.2
Total nonproductive	68.1	67.9	58.4	70.8	69.7	79.2	77.8
Annual grass	4.6	10.0	17.1	4.4	0.2	0.3	0.5
Annual weeds	3.3	1.0	0.5	1.0	1.6	1.9	2.1
Total	7.9	11.0	17.6	5.4	1.8	2.2	2.6
Moss	0.2	--	--	--	--	--	--
Perennial grass	8.4	0.5	0.5	0.7	2.2	0.9	1.2
Perennial weeds	2.2	0.2	0.2	0.2	0.4	0.3	--
Total	10.8	0.7	0.7	0.9	2.6	1.2	1.2
Sagebrush, *Artemisia tridentata*	6.7	12.2	9.7	17.4	8.9	6.3	5.1
Bitterbrush, *Purshia tridentata*	2.9	2.7	7.9	2.3	8.1	0.5	†0.9
Rabbitbrush, *Chrysothamnus* sp.	1.4	1.5	1.2	0.3	0.9	0.6	3.3
Horse brush, *Tetradymia* sp.	--	1.1	0.6	0.1	0.3	0.9	1.1
Desert peach, *Prunus Andersonii*	--	1.4	1.1	0.4	0.6	0.3	0.5
Mormon tea, *Ephedra* sp.	--	0.1	trace	0.2	1.1	3.3	2.0
Buckwheat, *Eriogonum* sp.	trace	--	--	0.1	0.8	3.7	1.2
Burrobrush, *Hymenoclea* sp.	--	--	--	--	0.1	--	1.2
Green leaf manzanita, *Arctostaphylos patula*	trace	trace	0.9	--	--	--	--
Curlleaf mahogany, *Cercocarpus ledifolius*	0.1	--	0.3	--	--	--	--
Squaw carpet, *Ceanothus prostratus*	1.2	trace	trace	--	--	--	--
Juniper, *Juniperus occidentalis*	0.4	0.6	--	--	--	--	--
Incense cedar, *Libocedrus decurrens*	--	--	0.9	--	--	--	--
Piñon pine, *Pinus cembroides*	--	--	--	1.3	--	--	--
Snow brush, *Ceanothus velutinus*	--	--	0.3	--	--	--	--
Bush lupine, *Lupinus* sp.	--	--	--	--	--	0.6	--
Greggs ceanothus, *Ceanothus Greggii*	--	--	--	--	0.9	--	0.4
Rose, *Rosa* sp.	--	--	--	--	0.3	--	--
Aspen, *Populus tremuloides*	--	0.1	--	--	--	--	--
Others	0.6	0.3	0.8	0.8	3.9	1.2	2.7
Total	13.2	20.4	23.3	22.9	25.9	17.4	18.4
Total vegetation	31.9	32.1	41.6	29.2	30.3	20.8	22.2

* LI = line intercept.
LP = line point.
† The bitterbrush species in this area is *Purshia glandulosa*.

TABLE A-2

Browse Age and Form Class Composition

(Shrubs on Forage Plots)

	Percentages of total shrubs in each class						
	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale	Tunawee Canyon
Bitterbrush age classes							
Seedlings	--	--	--	--	--	--	--
Young plants	32.3	4.3	7.2	17.4	3.8	22.3	6.3
Mature plants	45.6	52.2	77.1	60.9	66.9	44.4	--
Decadent plants	22.1	43.5	15.7	21.7	29.3	33.3	93.7
Sagebrush age classes							
Seedlings	0.3	--	--	0.5	--	--	--
Young plants	15.4	8.4	5.8	18.4	16.8	8.5	1.8
Mature plants	48.8	59.8	62.8	52.8	51.1	39.7	54.4
Decadent plants	35.5	31.8	31.4	28.3	32.1	51.8	43.8
Bitterbrush form classes							
All available, lightly hedged	15.3	4.8	20.5	24.6	10.9	11.1	--
All available, moderately hedged	57.9	12.3	37.4	20.3	30.4	55.5	25.0
All available, heavily hedged	26.3	74.9	31.3	55.1	52.2	11.1	75.0
Largely available, lightly hedged	--	0.6	3.6	--	--	--	--
Largely available, moderately hedged	0.5	2.1	3.6	--	2.7	22.3	--
Largely available, heavily hedged	--	3.9	3.6	--	3.8	--	--
Mostly unavailable	--	1.3	--	--	--	--	--
Sagebrush form classes							
All available, lightly hedged	59.4	65.7	48.1	82.3	61.7	88.7	--
All available, moderately hedged	32.7	30.7	41.0	12.7	27.4	9.4	12.3
All available, heavily hedged	7.6	3.6	10.9	4.4	10.6	--	84.1
Largely available, lightly hedged	--	--	--	0.6	0.3	1.9	3.6

TABLE A-3

Doe:Fawn Ratios

(Number of Fawns Per 100 Does)

Year	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
Fall								
1949-50	94	62	--	--	--	--	--	--
1950-51	77	49	--	--	62	56	49	58
1951-52	77	64	--	*75	89	72	58	73
1952-53	55	65	--	50	53	43	46	52
1953-54	96	77	99	84	75	41	59	76
1954-55	88	66	88	63	59	44	62	67
1955-56	73	50	66	42	50	30	37	50
Average (last 4 years)	78	65	--	60	59	40	51	--
Spring								
1949 50	--	12	--	--	--	--	--	--
1950-51	--	48	--	--	--	--	--	--
1951-52	34	29	--	*44	43	30	12	32
1952-53	--	64	--	50	48	39	29	46
1953-54	--	71	--	54	48	32	55	52
1954-55	71	46	72	35	46	31	35	48
1955-56	63	42	48	34	26	17	18	35
Average (last 4 years)	--	56	--	43	42	30	34	--

* Based on 64 fawns per 100 adults in February and 38 fawns per 100 adults in April and converted to doe:fawn ratio by estimated buck composition from findings of succeeding three years.

TABLE A-4

Bitterbrush Utilization

Year	Percentage of current growth utilized							
	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
Summer utilization by livestock								
1949-50	19	25	--	--	18	--	--	21
1950-51	10	28	--	--	11	--	--	16
1951-52	17	18	--	--	6	--	--	14
1952-53	7	23	25	14	5	1	--	13
1953-54	14	25	21	19	2	3	--	14
1954-55	9	26	22	26	6	1	--	15
1955-56	8	20	13	13	2	0	--	9
Average (last 4 years)	10	24	20	18	4	1	--	--
Winter utilization by deer								
1949-50	29	42	--	--	52	--	--	41
1950-51	30	34	--	--	39	43	70	43
1951-52	18	40	--	--	27	47	26	31
1952-53	16	26	28	44	25	19	30	27
1953-54	19	23	16	32	39	45	71	35
1954-55	45	30	28	34	48	42	68	42
1955-56	30	29	23	40	64	45	10	34
Average (last 4 years)	28	27	24	38	44	38	45	--
Total utilization (deer, livestock, rodents)								
1949-50	48	67	--	--	69	--	--	61
1950-51	40	62	--	--	51	43	70	53
1951-52	34	58	--	54	33	47	26	42
1952-53	23	49	53	58	30	22	30	38
1953-54	33	49	37	51	41	48	71	47
1954-55	53	56	50	60	54	43	68	55
1955-56	38	49	36	53	66	45	10	42
Average (last 4 years)	37	51	44	56	48	40	45	--

TABLE A-5

Sagebrush Utilization

Year	Percentage of current growth utilized							
	Devils Garden	Lassen-Washoe	Verdi	West* Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
Total utilization (deer, livestock, rodents)								
1949-50	9	13	--	--	25	--	--	16
1950-51	9	14	--	--	21	18	56	24
1951-52	9	13	--	--	23	24	62	26
1952-53	5	4	13	8/22	12	11	27	12
1853-54	7	4	7	10/17	12	7	25	10
1954-55	6	8	11	13/24	13	8	38	14
1955-56	6	8	14	15/--	31	9	29	16
Average (last 4 years)	6	6	11	12/--	17	9	30	--
Utilization by deer								
1949-50	9	10	--	--	15	--	--	11
1950-51	9	9	--	--	16	--	56	23
1951-52	9	10	--	--	18	--	62	25
1952-53	5	3	9	7/13	11	6	26	10
1953-54	6	3	6	9/13	11	6	25	9
1954-55	6	7	10	12/15	11	7	38	13
1955-56	5	7	12	13/--	31	7	29	15
Average (last 4 years)	6	5	10	10/--	16	7	30	--

* 8/22 indicates 8 percent utilization of big sagebrush and 22 percent utilization of black sagebrush.

TABLE A-6

Percentage of Bitterbrush Stand Over-browsed
(Percentage of Plots on Which Utilization Averaged 60 Percent or More)

Year	Percentage of total number of bitterbrush plots							
	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
After summer livestock use								
1949-50	--	5	--	--	8	--	--	6
1950-51	2	18	--	--	5	--	--	8
1951-52	0	7	--	--	0	--	--	2
1952-53	1	14	5	0	0	0	--	3
1953-54	0	8	16	7	0	0	--	5
1954-55	2	9	6	11	4	0	--	5
1955-56	0	4	3	8	0	0	--	3
Average (last 4 years)	1	9	8	7	1	0	--	--
Total after winter deer use								
1949-50	40	63	--	--	78	--	--	60
1950-51	20	64	--	--	43	47	77	50
1951-52	17	52	--	53	18	33	22	33
1952-53	5	33	35	54	10	0	0	20
1953-54	11	28	32	57	21	60	100	44
1954-55	46	56	43	70	38	0	83	48
1955-56	20	31	18	54	78	60	0	37
Average (last 4 years)	21	37	32	59	37	30	46	--
Percentage attributed to deer								
1949-50	--	58	--	--	70	--	--	64
1950-51	18	46	--	--	38	47	77	45
1951-52	17	45	--	--	18	33	22	27
1952-53	4	19	30	54	10	0	0	19
1953-54	11	20	16	50	21	60	100	40
1954-55	44	47	37	59	34	0	83	44
1955-56	20	27	15	46	78	60	0	34
Average (last 4 years)	20	28	25	52	36	30	46	--

TABLE A-7

Bitterbrush Leader Growth

Year	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
Average uncropped leader length, inches								
1949-50	3.5	3.4	--	--	--	--	--	3.4
1950-51	3.2	3.1	--	--	3.2	--	--	3.2
1951-52	3.7	5.1	--	--	4.7	--	--	4.5
1952-53	5.4	3.5	4.8	5.4	*(4.9)	6.3	--	5.1
1953-54	3.8	3.6	3.9	2.7	2.1	2.5	--	3.1
1954-55	3.2	2.6	2.7	2.5	2.7	2.6	--	2.7
1955-56	3.0	2.6	2.7	1.8	1.8	1.6	--	2.2
Average (last 3 years)	3.3	2.9	3.1	2.3	2.2	2.2		--
Inches of growth cropped by livestock								
1949-50	0.7	0.9	--	--	--	--	--	0.8
1950-51	0.3	0.9	--	--	0.4	--	--	0.5
1951-52	0.6	0.9	--	--	0.3	--	--	0.6
1952-53	0.4	0.8	1.2	0.8	0.2	0.1	--	0.6
1953-54	0.5	0.9	0.8	0.5	trace	0.1	--	0.5
1954-55	0.3	0.7	0.6	0.6	0.2	0.1	--	0.4
1955-56	0.2	0.5	0.4	0.2	0.3	0.0	--	0.3
Average (last 3 years)	0.3	0.7	0.6	0.4	0.2	0.1	--	--
Inches of growth cropped by deer								
1949-50	1.0	1.4	--	--	--	--	--	1.2
1950-51	1.0	1.0	--	--	1.2	--	--	1.1
1951-52	0.7	2.0	--	--	1.3	--	--	1.3
1952-53	0.9	0.9	1.3	2.4	1.2	1.2	--	1.3
1953-54	0.7	0.9	0.6	1.0	0.8	1.1	--	0.9
1954-55	1.4	0.8	0.8	0.9	1.3	1.1	--	1.1
1955-56	0.9	0.8	0.6	0.7	1.1	0.7	--	0.8
Average (last 3 years)	1.0	0.8	0.7	0.9	1.1	1.0	--	--

* Large secondary leaders were averaged together with primary leaders on this range in 1952-53, resulting in a conservative figure. Computations indicate the average length of primary leaders was close to 6.5 inches.

TABLE A-8

Pellet Group Counts
(Number of Groups Per Acre)

Year	Devils Garden	Lassen-Washoe	Verdi	West Walker	Butter-milk	Goodale Creek	Tunawee Canyon	Average
1949-50	260	261	--	--	375	--	--	299
1950-51	309	276	--	--	511	--	--	365
1951-52	221	438	--	471	474	319	311	372
1952-53	132	236	410	242	403	185	457	295
1953-54	293	217	248	234	455	140	419	287
1954-55	277	380	371	370	707	165	301	367
1955-56	248	223	289	387	424	142	287	286
Average (last 4 years)	237	264	330	308	497	158	366	--

TABLE A-9

Doe:Fawn Ratios From Other Ranges

	Fawns per 100 does by years*				
	1951-52	1952-53	1953-54	1954-55	1955-56
Great Basin ranges—fall					
Miller Mountain, Siskiyou County	63	45	81	76	35
Glass Mountain, Siskiyou-Modoc counties	77	68	93	86	81
Warner Mountains, Modoc County	--	57	92	85	81
Jacks Valley, Nevada	--	66	73	73	(47)
Carson River, Alpine County	--	51	70	78	52
Other California ranges—fall					
Oak Knoll, Siskiyou County	64	54	69	55	59
Hartstrand Gulch, Siskiyou County	46	51	70	51	44
Tehama State Game Range, Tehama County	62	56	76	65	56
Bartons Flat, Fresno-Tulare counties	--	--	70	69	45
San Joaquin River, Madera County	61	41	100	61	--
San Benito River, San Benito County	63	71	102	--	92
Great Basin ranges—spring					
Miller Mountain, Siskiyou County	33	--	--	47	31
North Warner Mountains, Modoc County	--	35	86	53	50
South Warner Mountains, Modoc-Lassen counties	--	56	74	36	32
Jacks Valley, Nevada	--	50	63	58	(30)
Carson River, Alpine County	--	43	67	63	35
Other California ranges—spring					
Oak Knoll, Siskiyou County	40	61	--	49	43
Hartstrand Gulch, Siskiyou County	37	35	--	53	45
Tehama State Game Range, Tehama County	--	63	--	41	55
San Benito River, San Benito County	6	58	--	--	--

* Figures in parentheses represent fawns per 100 adults.

A NOTE ON THE FOOD OF SAGE GROUSE IN THE MADELINE PLAINS AREA OF CALIFORNIA[1]

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A previous study of the food habits of sage grouse in California (Leach and Hensley, 1954) revealed the staple item of diet for the birds examined to be the leafage of common sagebrush. Also contributing to the diet of the 135 sage grouse taken in Mono County were leafage of clover (*Trifolium* sp.), juncus (*Juncus* sp.), snowberry (*Symphoricarpos rotundifolius*), and unidentified forbs. Forty birds examined from Lassen County contained a predominance of sagebrush leafage, prickly lettuce flowers, wooly sunflower leafage, and grasshoppers (*Melanoplus* spp.).

A continuation of a limited hunting season in 1955 in Modoc and Lassen counties permitted a further sampling of sage grouse foods. A collection of 85 stomachs was made from hunter-killed birds at the Madeline Plains Waterfowl Management Area, located in central Lassen County, during the 1955 season (September 3-4) by Rod McLaughlin and Tom Ramsey, regional personnel.

The purpose of the collection was to determine the contribution of agricultural crops grown on this waterfowl management area to the diet of the sage grouse. A relatively large population of sage grouse normally inhabits the Madeline Plains, and a portion of this population is common to the Madeline Plains Waterfowl Management Area. This unit is managed by the California Department of Fish and Game to provide fall and spring food for migrant waterfowl. Over the past years, approximately 700 acres of the 5,176 acres of the waterfowl management area have been under cultivation. With the exception of 40 acres of alfalfa in 1954-55, barley and wheat constitute the agricultural crops grown for waterfowl usage. The private land contiguous to the management area is devoted to grain growing, with some acreage in permanent pasturage.

The vegetation of the Madeline Plains, exclusive of the area influenced by agricultural disturbance, is typical of the Great Basin sagebrush climax formation. Sagebrush dominates the flats and extends uninterrupted to the slopes of the bordering mountains, where bitterbrush (*Purshia tridentata*) and Sierra juniper (*Juniperus occidentalis*) appear in association. Rabbitbrush, cheat grass, and poverty weed constitute the other principle ground cover species.

With the advent of agriculture into the Madeline Plains has come the introduction of many weeds commonly associated elsewhere with

[1] Submitted for publication September, 1957. This study is a contribution from Federal Aid in Wildlife Restoration Project California W-52-R, "Wildlife Investigations Laboratory".

FIGURE 1. A view on the Madeline Plains Waterfowl Management Area. The coarse plants in the foreground are prickly lettuce. This common weed produces numerous flowers in open panicles which are attractive to sage grouse, and contributes substantially to the fall diet. *Photograph taken September, 1957, by Howard R. Leach.*

grain growing areas. Among these weed pests are prickly lettuce, penny cress, tumbling mustard (*Sisymbrium altissimum*), and lamb's quarters. These plants and many other annual weeds grow rank along the ditchbanks, fence rows, roadsides, and in the fallow fields and dikes on the waterfowl management area—quite in contrast with the adjacent sagebrush climax formation. In many of the diked units, water manipulation has virtually eliminated the sagebrush. A secondary succession to emergent vegetation, primarily common spikerush, has resulted wherever favorable moisture conditions exist.

The results of the laboratory analyses of the 85 sage grouse stomachs collected are shown in Table 1. This table gives the volume in percentage and frequency of occurrence in percentage of the food items identified in the stomachs.

The principal food proved to be the flowers of prickly lettuce. It made up 50.0 percent of the diet by volume and was found in 90.6 percent of the stomachs. In the previous study, this plant was found to be second in importance only to sagebrush in the vegetative diet of the sage grouse collected from the Bull Flat and Line Spring areas in Lassen County. Without doubt, prickly lettuce is an acceptable food and may be considered to be an important seasonal item in the diet of the sage grouse.

The leafage and flowers of sagebrush contributed the remaining bulk to the food of the Madeline Plains sage grouse. This staple item of the

TABLE 1

Food Items Eaten by 85 Sage Grouse Collected at Madeline Plains, Lassen County September 3-4, 1955

Scientific name	Common name	Parts eaten	Volume (percentage)	Frequency of occurrence (percentage)
Plant food				
Lactuca scariola	Prickly lettuce	Flowers	50.0	90.6
Artemisia tridentata	Common sagebrush	Leafage, flowers	31.6	65.9
Medicago sativa	Alfalfa	Leafage	8.7	11.8
Chrysothamnus viscidiflorus	Rabbitbrush	Leafage	3.1	9.4
Iva axillaris	Poverty weed	Leafage, seeds	1.9	31.8
Vicia sp.	Vetch	Leafage	1.6	4.8
	Unidentified forbs	Leafage	1.1	16.5
Eriophyllum lanatum	Wooly sunflower	Flowers	0.1	43.5
Triticum aestivum	Wheat	Seeds	0.1	7.2
Bromus tectorum	Cheat grass	Seeds	trace	15.3
Gramineae	Unidentified grass	Seeds	trace	7.2
Gramineae	Unidentified grass	Leafage	trace	3.6
Eleocharis palustris	Common spikerush	Leafage	trace	1.2
Polygonum aviculare	Wiregrass	Seeds	trace	10.6
Eriogonum sp.	Buckwheat	Seeds	trace	2.4
Chenopodium album	Lambsquarter	Seeds	trace	1.2
Chenopodium sp.	Pigweed	Seeds	trace	2.4
Thlaspi arvense	Penny cress	Seeds	trace	1.2
Oenothera tanacetifolia	Primrose	Flowers	trace	3.5
Phlox sp.	Phlox	Seeds	trace	5.9
Cirsium occidentale	Western thistle	Seeds	trace	1.2
	Unidentified seeds		trace	1.2
	Vegetative stem fragments		trace	1.2
	Insect galls		trace	3.5
Animal food				
Formicidae	Ants		1.6	78.8
Calosoma semiloeve	Common black calosoma		0.2	1.2
Hippodamia sp.	Ladybird beetle		trace	37.6
Insecta	Unidentified insects		trace	31.8

diet was found in 65.9 percent of the stomachs and contributed 31.6 percent of the food by volume.

Of the cultivated plants present in the area, both wheat and alfalfa were found to have been eaten. Despite the fact a number of the birds were killed in the wheat fields and adjacent areas, there appears to be little evidence to indicate that the birds were utilizing the ripened grain to any great extent. Wheat was found in but 7.2 percent of the stomachs and bulked only 0.1 percent of the diet. Alfalfa, however, may be an important supplementary food for the sage grouse, especially during another season of the year. Although at the time of the collection it occurred in only 10 (11.8 percent) of the birds examined, it did constitute the bulk of the food in the stomachs of those individual birds.

The remaining plant foods contributing materially to the diet (7.8 percent by volume) consisted of the leafage of sticky-flowered rabbitbrush, poverty weed, vetch, unidentified forbs, and the flowers of wooly sunflower.

Animal food made up the remaining portion of the diet (1.8 percent). This food consisted primarily of ants and ladybird beetles. Ants made up 88.9 percent of the animal food by volume and were found in 78.8 percent of the stomachs.

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A TECHNIQUE FOR OBTAINING FOOD HABITS MATERIAL FROM NESTLING DOVES[1]

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A knowledge of the food habits of the mourning dove (*Zenaidura macroura*) in different habitats and at different seasons of the year is of importance to a fuller understanding of the species. More knowledge of dove food habits would make it possible to judge the economic effects of the species on agriculture and would also give clues to the types of agricultural and management practices favorable for dove food production.

Usually food habits studies are made by analyzing the crop contents of shot specimens. Rosene (1939), McClure (1943), Korschgen (1955), and others have published works on the food habits of doves gathered by this method.

Lack (1954) pointed out that one difficulty with this method in area population studies is that the collection of specimens will reduce the population. Alternative methods of collecting food habits data are therefore desirable.

Lack (*op. cit.*) summarizes several alternative methods of studying the food of nestling birds. Cormorants and herons readily disgorge their last meal when frightened. If a parent common swift with food for its young is caught on the nest, it ejects the whole food ball from the back of its throat. If a young swift is taken just after being fed, the food can easily be manipulated up from its throat. This article is concerned with a variation of this last procedure to obtain food habits data on nestling mourning doves.

Members of the dove and pigeon family feed their young a substance called "pigeon milk". This substance is composed of thickened epithelial cells of the crop wall, whose growth has been stimulated by the hormone prolactin. These cells proliferate at a rapid rate and are then sloughed off to form the curdy substance called "pigeon milk". Nestling doves are fed this "pigeon milk" for the first few days and then as they develop are fed a mixture of "pigeon milk" and whatever food the parent birds have been eating. By the time the nestlings are about eight days old the "pigeon milk" makes up a minor portion of the crop contents and the majority of the diet of the nestlings is composed of regurgitated seeds brought in by the parent birds. This trait makes it possible to obtain food habits data by flushing out the crop contents of the nestling birds. This same procedure could be used

[1] Submitted for publication July, 1957. This study was made with funds provided by Federal Aid in Wildlife Restoration Act, Project California W-47-R, "Upland Game Investigations".

whenever birds possessing a crop are trapped by any means other than attraction through the use of bait.

The first attempts to obtain nestling crop contents were made by applying a slight vacuum to a tube inserted in the crop. This did not prove sufficiently successful, so efforts were switched to obtaining crop contents by flushing out the crop with water. This proved to be a satisfactory procedure. During the 1956 nestling season, 160 crop contents were obtained by this method, with only two casualties experienced. No attempts were made to obtain crop contents from very young birds and usually crop contents were obtained only from birds six days of age or older.

When nests contain nestlings of the appropriate age, the crops of the birds are checked by appearance and feel to determine the amount of food present. If the crop is more than half full, the crop contents are collected in the following manner. The collector uses a four-inch tube, which is made by cutting a plastic straw in half, and half a mouthful of water. The tube is inserted in the dove's crop and a small quantity of water is blown into the crop. It is well to fill the tube with water before inserting it in the crop, so that the crop is not blown up with air. After the water is in the crop, the crop contents can be manipulated out and collected in a small square of cloth. The excess moisture is then squeezed from the sample, and the cloth is gathered and tied so as to form a small bag. The bag is labeled and dried for analysis of the food items at a later date.

No attempt should be made to flush out the entire contents, since this would disturb the birds unduly. Some bias is introduced in that the larger seeds are harder to flush out; however, the collector can check the crop by feeling for these larger seeds and make due allowance for them.

Although dove nests have been recorded for every month of the year in California, the normal nesting period is from March through August, with a few nests still occurring in some areas during the first week of September. This long nesting period makes it possible to use this technique to obtain food habits data over a six-month period without the removal of any birds from the population.

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THE FISHERY FOR SABLEFISH, *ANOPLOPOMA FIMBRIA*[1]

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INTRODUCTION

The sablefish or black cod, *Anoplopoma fimbria*, forms the basis of a moderate but important fishery along the Pacific Coast from California to Alaska. This fishery is one of the oldest on our coast, having started during the last decade of the 19th century off Washington and British Columbia, whence it expanded to California, Oregon, and Alaska. Prior to 1913 it was of rather minor significance, but the demand created for fisheries products by World War I greatly stimulated the fishery, and in 1917 about 13 million pounds were landed on the Pacific Coast. Between the stimulus of World War II and a strong demand for the natural Vitamin A yield of sablefish livers and viscera, annual landings reached 15 million pounds in 1946. Since then a readjustment of the market and competition from other sources of Vitamin A have resulted in average annual landings of about nine million pounds along the Pacific Coast. California contributes about two million pounds to this total.

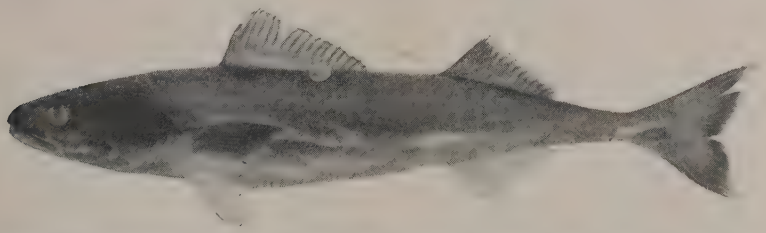

FIGURE 1. Sablefish or black cod. Note the tag bearing a serial number, attached just under the first dorsal fin. This tag, known as a Petersen tag, consists of two plastic disks and a stainless steel wire pin. A disk is placed on either side of the fish and these are held in position by the pin, which fits through a small hole in the center of each disk. *Photograph by J. B. Phillips.*

An apparent decline in sablefish populations on some fishing banks prompted the Pacific Marine Fisheries Commission in 1950 to recommend that the various fisheries agencies along the Pacific Coast conduct a joint study of this fishery. The member states of Washington, Oregon, and California were joined voluntarily by Canada and Alaska in this research program. The main objective was to determine if the population of sablefish along the coast formed one large, rather homo-

[1] Submitted for publication July, 1957.

geneous unit, or if there were a number of essentially distinct stocks. In the former case, any necessary regulations would need to be applied to the population as a whole, while in the latter case regulations would need to be considered on a regional basis. In addition, life history studies were conducted by the agencies to provide information necessary in a management program.

A major portion of this program was completed and the results published in 1954. Studies on the annual yield per unit of effort and evaluation of current tagged fish returns are being continued.

DISTRIBUTION

Sablefish are found along the Pacific Coast from northern Baja California northward into the Bering Sea, but are not abundant south of Monterey, California. Adults of this species are demersal and are most abundant over a clay or hard mud bottom. They are less abundant over sand, rock, and other types of substrate. Although adult fish are sometimes taken in water as deep as 400 fathoms (2,400 feet), immature fish are found in shallower waters, and very young fish may be found near the surface.

During the spawning season, which occurs from winter to early spring, mature fish are most abundant on the bottom in waters of 200 to 400 fathoms. Following spawning, the spent mature fish shift back into waters of lesser depth, and best fishing for large sizes is found in 100 to 175 fathoms.

MARKETS

The importance of the sablefish fishery in California has been increasing gradually over the years, primarily because of a wider acceptance of the smoked product. For this purpose, large fish are cleaned and beheaded, with a loss of about one-third from round weight, then frozen and shipped to fish curers. The smoking or kippering of this fish closely follows the procedure used on salmon. The popularity of sablefish in the smoked form dates to about 1910, when leading hotels and restaurants in the Puget Sound region commenced featuring "Barbecued Alaska Black Cod".

Smoking of sablefish in California started about 1915, and until 1945 virtually the entire production of the State was centered at San Francisco. At that time the Los Angeles area broke into prominence, and since 1948 nearly as much of the smoked product has been processed there as at San Francisco. The amount of this fish smoked in California increased from about 200,000 pounds in 1925 to about 500,000 pounds in 1955. Additional sablefish is shipped in a frozen condition to eastern states, where it is smoked.

A nominal amount of sablefish is accepted by a component of the fresh fish trade that is fond of fish flesh high in fat content. Before refrigeration and freezing became widespread, a considerable quantity was salted, particularly when cheaper grades of salt salmon were in short supply. During some recent years there has been a limited amount of sablefish salted for export, primarily to the Hawaiian Islands.

In earlier years, because of the demand for Vitamin A, the sale of livers from certain species of marine fishes, such as sablefish, was a

lucrative by-product of these fisheries. But, in 1947 the market for domestic fish livers suffered a severe deterioration because of commercial production of Vitamin A at a lower price.

FISHING GEAR

Longlines or setlines (multiple-hook lines) and otter trawls (drag nets) are the two types of fishing gear that account for nearly all of the sablefish caught off California, as well as along the balance of the Pacific Coast. For many years, otter trawl operations in California were conducted primarily for flatfish and rockfish, with sablefish forming an incidental catch. While this is still largely true, more extensive exploitation of deeper waters in recent years has resulted in the trawlers obtaining greater amounts of large sablefish. Nevertheless, dealers offer a higher price for large fish caught with setlines, because they are in superior condition when delivered at the dock.

FIGURE 2. A fisherman setting baited longline or setline gear for sablefish about 10 miles off Eureka, California. The gear is set while the vessel is underway, with the gear in the separate tubs being fastened together to form one continuous string. An anchor, up-and-down line, and buoy are attached to each end of the string. *Photograph by J. B. Phillips.*

The hook-and-line gear used in California in the sablefish fishery during the last two decades was the result of a compromise between longlines, the heavy gear with widely-spaced, large hooks used in the halibut fishery, and setlines, the relatively light gear with closely-spaced, small hooks which originated in central California for the purpose of catching rockfish and similar fishes of medium and small size.

Whereas the conventional Californian method is to coil setlines in flat wicker baskets, a few fishermen at Eureka continue to coil their setlines into tubs, which have been used for many years as containers for the heavier halibut longline gear.

TAGGING

As a result of a tagging program carried out by the various fisheries agencies along the Pacific Coast, it was found that the stocks of sablefish from California to Cape Spencer, in southeastern Alaska, do not intermingle extensively. North of Cape Spencer, Alaskan biologists found that a number of fish tagged in the outside waters of the Gulf of Alaska had migrated varying distances, mainly southward. One fish tagged 50 miles off Cape Cleare was recovered a year later off Cape Flattery, Washington, a distance of 1,230 miles to the south. Recently a reciprocating trip was completed in 15 months by a fish tagged in Puget Sound by Washington biologists. This fish was recovered at Middleton Island, in the Gulf of Alaska, a distance of about 1,100 miles northward from the locality of release. However, most of the tagged fish recoveries, some of which have been at liberty for five years, have been made within 30 miles of the point of release. In California, only 8 of 185 recoveries were from fish that had moved more than 32 miles. Four of these had migrated in a northerly and four in a southerly direction. The greatest distance traveled by a California-tagged fish was 450 miles—from off Fort Bragg to Grays Harbor, Washington. This fish was at liberty 19 months before being recaptured.

RACIAL STUDIES

The different agencies contributed samples of sablefish taken from various localities along the Pacific Coast, from southern California to Cape Spencer, Alaska. Numerous meristic counts were made on all these fish and chi-square tests applied to the results. These tests indicated that between southern California and Cape Spencer, Alaska, there are at least four major regional stocks, with probable further separations within these regions where intermingling does not appear to be extensive.

Inasmuch as both racial and tagging studies indicated that there was only limited intermingling of fish between certain regions, it was determined that the stocks of sablefish along the Pacific Coast could not be regulated as one large, single unit.

AGE AND MATURITY

Age studies show that a total length of about 13 inches is attained by sablefish at the end of the first year. In succeeding years males grow more slowly than do females, and fail to reach as large a maximal size. At a length of 24 inches and an age of five years, approximately 50 percent of the males are mature; at a length of 28 inches and an age of seven years, 50 percent of the females are mature. At these sizes, a male weighs about four pounds and a female, six and one-half pounds. It is estimated that a 40-inch fish, weighing about 23 pounds, is about 20 years old.

Observations on the gonads of sablefish landed at the ports of Eureka, Fort Bragg, and Monterey show that the main spawning period is December through April, with peak spawning in January and February. At first maturity, a female will spawn about 100,000 eggs, but with increasing age and size, greater numbers of eggs are spawned. A 40-inch female will spawn about 1,000,000 eggs in a season. The eggs are of the free-floating, pelagic type, and fertilization takes place externally.

During the period 1950-1953, measurements and other data were taken on some 7,000 sablefish caught by setline boats working from the ports of Eureka, Fort Bragg, and Monterey. The largest male encountered was 35 inches in total length and the largest female was 42 inches. Because females attain a maximal length that is appreciably greater than that of males, the sex ratio varies between small and large fish, with females predominating in the larger sizes.

ABUNDANCE

An analysis of the setline fishery at the ports of Eureka, Fort Bragg, and Monterey-Santa Cruz was made. This study indicated that the annual average pounds per boat trip has remained relatively constant during the postwar period, 1946-1955. During this period, however, there has been a downward trend both in the number of boats and the number of deliveries at all ports.

Annual fluctuations in the catch are associated with demand. Inasmuch as the largest portion of the catch is placed in cold storage for future smoking, it has been found that a large cold storage holding in one year is associated with a relatively low catch in the ensuing year, and vice versa. Dealers exercise control over the catch by limiting the number of deliveries or by reducing the price paid fishermen, until a point is reached where the fisherman decides that he cannot obtain a fair return and stops fishing for this species.

Because the return per unit of effort is being maintained and because there have been no recent, unusual developments in the utilization of sablefish, regulation of the fishery in California is not being proposed at this time.

In contrast with the situation in California, the stocks of sablefish off the Oregon and Washington coasts appear to be in need of some protection because of a gradual downward trend in the return per unit of effort, and a concurrent decline in the sizes of fish caught. Several suggestions are being considered, such as closure of certain areas where small fish are known to exist, minimum size limits, and a seasonal closure. In the meantime, some benefit should accrue from an increase to four and one-half inches in the minimum size of mesh permitted in otter trawls operating in the Pacific Northwest. California has had this minimum mesh restriction for a number of years and, in addition, otter trawling is not permitted within three miles of the mainland and around the offshore islands as far south as the Santa Barbara-Ventura county line. Southward of this line, the possession of otter trawls or other types of drag nets is prohibited.

SUMMARY

Sablefish or black cod, *Anoplopoma fimbria,* are found in the ocean waters along the Pacific Coast of North America from northern Baja California northward into the Bering Sea, but are not abundant southward of Monterey, California.

This species is the object of a moderately important commercial fishery, based primarily on the demand for the product in a smoked or kippered form. Annual fluctuations in the catch are associated with demand. Since a large portion of the catch is placed in cold storage for future smoking, a large cold storage holding in one year is associated with a relatively low catch in the ensuing year, and vice versa.

Racial and tagging studies indicated that there are several stocks of sablefish along the Pacific Coast. Since intermingling of these stocks or subpopulations was determined to be negligible, any contemplated regulations would have to be applied on a regional basis. Although there has been an apparent decline in the stock of sablefish off Oregon and Washington, no evidence has been found to indicate a depleted condition of the stocks in the northern and central California regions.

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REVIEWS

The Search Beneath the Sea

By J. L. B. Smith; Henry Holt and Company, New York, 1956; xiv + 260 p., illus. $3.95.

I was fully prepared to read a lengthy technical discourse about the Coelacanth, complete with tiresome graphs and tables and written in the usual dull style so popular with fishery workers.

Imagine my surprise to discover that the author's style of writing is as refreshing and salty as a sea breeze and as rare among ichthyologists as the Coelacanth about which he writes.

Professor J. L. B. Smith presents an authentic behind-the-scenes story concerning the discovery of the first Coelacanth and his successful 14-year search for a second.

This book can be divided into four general sections. The first is a short autobiography, providing a background for the rest of the story. The next section is concerned with the discovery and identification of the first living Coelacanth and also informs the reader where this ancient fish fits into the geologic past and the evolutionary scheme of life. A third section deals with the trials and tribulations of the author's prolonged search for another specimen. The final part is especially valuable. It consists of several appendices that explain how the Coelacanth differs from most modern fishes, why its discovery aroused such wide interest, its origin and importance, and the present status of the Coelacanth investigation.

During the course of the story of this primitive vertebrate, believed to have been extinct for over 50 million years, the author never hesitates to name the people responsible for his success and failures nor to give his frank opinion of many leading scientists and public officials, as well as of himself.

This book should be of interest to the layman as well as the ichthyologist.—*Harold B. Clemens, California Department of Fish and Game.*

A Contribution to the Heritage of Every American

By Nancy Newhall; Alfred A. Knopf, New York, 1957; x + 179 p., illus. with color photographs, drawings, and maps. $13.50.

Nancy Newhall and a host of noted artists and craftsmen have worked together with Knopf to produce a beautiful volume for the book collector as well as for the conservationist. This is a big book, measuring about 13 inches x 9 inches x 1 inch. It contains 138 illustrations, 44 of which are in color, including 17 full-page photos and magnificent end papers of a panoramic view of Yosemite by Ansel Adams. Photos have also been contributed by Alfred Eisenstaedt, Allan D. Cruikshank, Frank and John Craighead, the twin ornithologists of falconry fame, and many others.

There is a prologue by the late conservationist Fairfield Osborn, and an epilogue by Horace M. Albright, of the National Park Service. The type and the reproduction of the illustrations are flawless.

It is not often that such an historical and artistic book finds its way into the review section of a scientific journal. In this case, however, it seemed proper to bring to light the little known conservation activities of John D. Rockefeller, Jr. Although to many Mr. Rockefeller represents big business, with its supposed ruthless disregard for natural resources, the book reveals that he spent much of his life and untold millions of dollars to preserve some of America's most beautiful and breathtaking wilderness. His search for these lands extended from Arcadia on Mt. Desert Island, Maine (our first National Park east of the Mississippi) to the recently formed Virgin Islands National Park and to the State and National Parks containing the famous redwoods of California.

Philosophically, the book emphasizes preservation. In the conflict involving the three ideas of exploitation for gain, conservation for use, and conservation for the benefit and enjoyment of the people, it is clear which one was held by Mr. Rockefeller. Nowhere is the theory of harvest and sustained yield mentioned, although it is believed that perpetual public hunting rights have been reserved in part of the famous Jackson Hole Basin, another of Mr. Rockefeller's projects.

Californiaphiles will be proud to learn that 13 percent (22 pages) of the book is devoted to their State. Furthermore, a California Coast Redwood is listed as the tallest living thing, a statement our Australian biologist friends might challenge with measurements of one of their many species of eucalyptus trees. Many of the photos are scenic, only. But, on page 151 there is a rather appalling view of an abandoned, cutover ravine where once a healthy stand of conifers existed. There is nothing in the text about the logging practices which caused this—the picture speaks for itself.

If there is any fault to find with the book, it is minor. Personally, I would prefer to have more scenes from the National Parks and fewer of the details of the restoration of Colonial Williamsburg. In addition, although the general photo standards are excellent, many of the black-and-white photos are of the tourist type or what one sees in some of the less imaginative of the National Park Service folders, where adults and children listen eagerly, mouths agape, to the Park Ranger as he gives his talk. And finally, I regret that there was not more consideration given to wildlife, and in particular to the modern theories of management of renewable resources. This was not, however, Mr. Rockefeller's approach, and one can scarcely ask for more from any one man than the gifts he gave America. Let's hope that he is not the last of our truly great philanthropists.—*Herbert E. Pintler, California Department of Fish and Game.*

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